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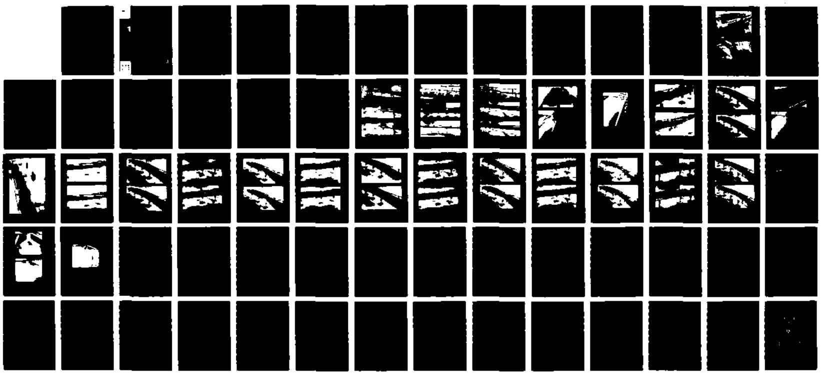

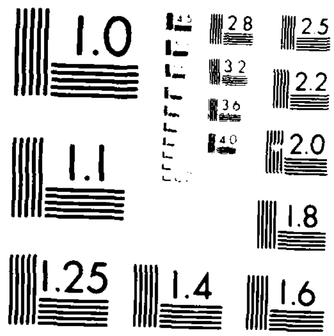

MICROCOPY RESOLUTION TEST CHART

(4)

US Army Corps of Engineers

AD-A187 714

TECHNICAL REPORT HL-87-14

WALNUT CREEK FLOOD-CONTROL PROJECT CONTRA COSTA COUNTY, CALIFORNIA

Hydraulic Model Investigation

by

W. G. Davis

Hydraulics Laboratory

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
PO Box 631, Vicksburg, Mississippi 39180-0631

US ARMY ENGINEER WATERWAYS EXPERIMENT STATION

October 1987

Final Report

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19 ABSTRACT (Continue on reverse if necessary and identify by block number)

Tests were conducted on a 1:25-scale model of the Walnut Creek channel to determine the adequacy of proposed channel improvements for the Walnut Creek channel, the San Ramon Bypass Channel, and their junction. The model reproduced approximately 1,084 ft of the San Ramon Bypass Channel, 730 ft of the Walnut Creek channel upstream from the junction, with topography reproduced upstream from the entrance to the revised channel, and 640 ft of the existing Walnut Creek channel downstream from the junction. The model was constructed so that the slopes of the channels could be adjusted to reproduce various energy gradients equivalent to those resulting from different prototype Manning's n roughness factors.

The slopes of the model were initially adjusted to produce an energy gradient resulting from a Manning's n roughness factor of 0.012 in the prototype. Unsatisfactory flow conditions were observed in the Walnut Creek channel upstream from the junction due to entrance conditions into the high-velocity channel. A wall was installed which bridged the

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access ramp and provided satisfactory flow conditions in the portion of Walnut Creek upstream from the junction. Flow exceeded the wall heights at several points downstream from the San Ramon-Walnut Creek junction for both design flows with their maximum concurrent flows.

A 40-ft-long divider extension installed at the junction greatly improved flow conditions in the channel downstream and eliminated overtopping of the channel walls.

The slopes of the high-velocity channel were adjusted to reproduce the energy gradient resulting from a Manning's n roughness factor of 0.014 in the prototype. For both design flow conditions, overtopping of the wall heights was observed in the Walnut Creek channel. The width of the San Ramon Bypass Channel was reduced by 1 ft to 23 ft just upstream of the junction and the channel alignment was improved at the junction; the slope of the Walnut Creek channel was increased to 0.005 ft/ft downstream from the junction with this slope maintained in the San Ramon Bypass Channel upstream from the junction to sta 584+98; and the slope of the Walnut Creek channel upstream from the junction was increased to 0.0185 ft/ft extending to sta 584+50. These modifications provided satisfactory flow conditions for both design flows in the high-velocity channels. However, by steepening the slopes in the Walnut Creek channel, the upstream elevation of the channel invert was increased 1.5 ft, which increased the upstream pool elevation to an undesirable level. When flow through the access ramp was blocked, channel efficiency was increased and a satisfactory pool elevation was achieved with the design flow in Walnut Creek.

PREFACE

The model investigation reported herein was authorized by the Office, Chief of Engineers (OCE), US Army, on 20 June 1983 at the request of the US Army Engineer District, Sacramento (SPK). The studies were conducted by personnel of the Hydraulics Laboratory (HL), US Army Engineer Waterways Experiment Station (WES), during the period January 1984 to December 1985. All studies were conducted under the direction of Messrs. H. B. Simmons, former Chief of HL, F. A. Herrmann, Jr., Chief of HL, and J. L. Grace, Jr., Chief of the Hydraulic Structures Division. The model components were constructed and assembled by Mr. E. B. Williams, Engineering and Construction Services Division, WES. The tests were conducted by Messrs. W. G. Davis and R. G. Frazier, Locks and Conduits Branch, under the supervision of Messrs. G. A. Pickering, former Chief of the Locks and Conduits Branch, and J. F. George, Acting Chief of the Locks and Conduits Branch. This report was prepared by Mr. Davis and edited by Mrs. Marsha Gay, Information Technology Laboratory.

Messrs. Ted Albrecht of the South Pacific Division; Harold Huff and Les Dixon of SPK; and Tom Munsey of OCE visited WES during the study to discuss test results and to correlate these results with concurrent design works.

COL Dwayne G. Lee, CE, is the Commander and Director of WES. Dr. Robert W. Whalin is the Technical Director.

CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	by	To Obtain
acres	4,046.873	square metres
cubic feet	0.02831685	cubic metres
degrees (angle)	0.01745329	radians
feet	0.3048	metres
miles (US statute)	1.609347	kilometres

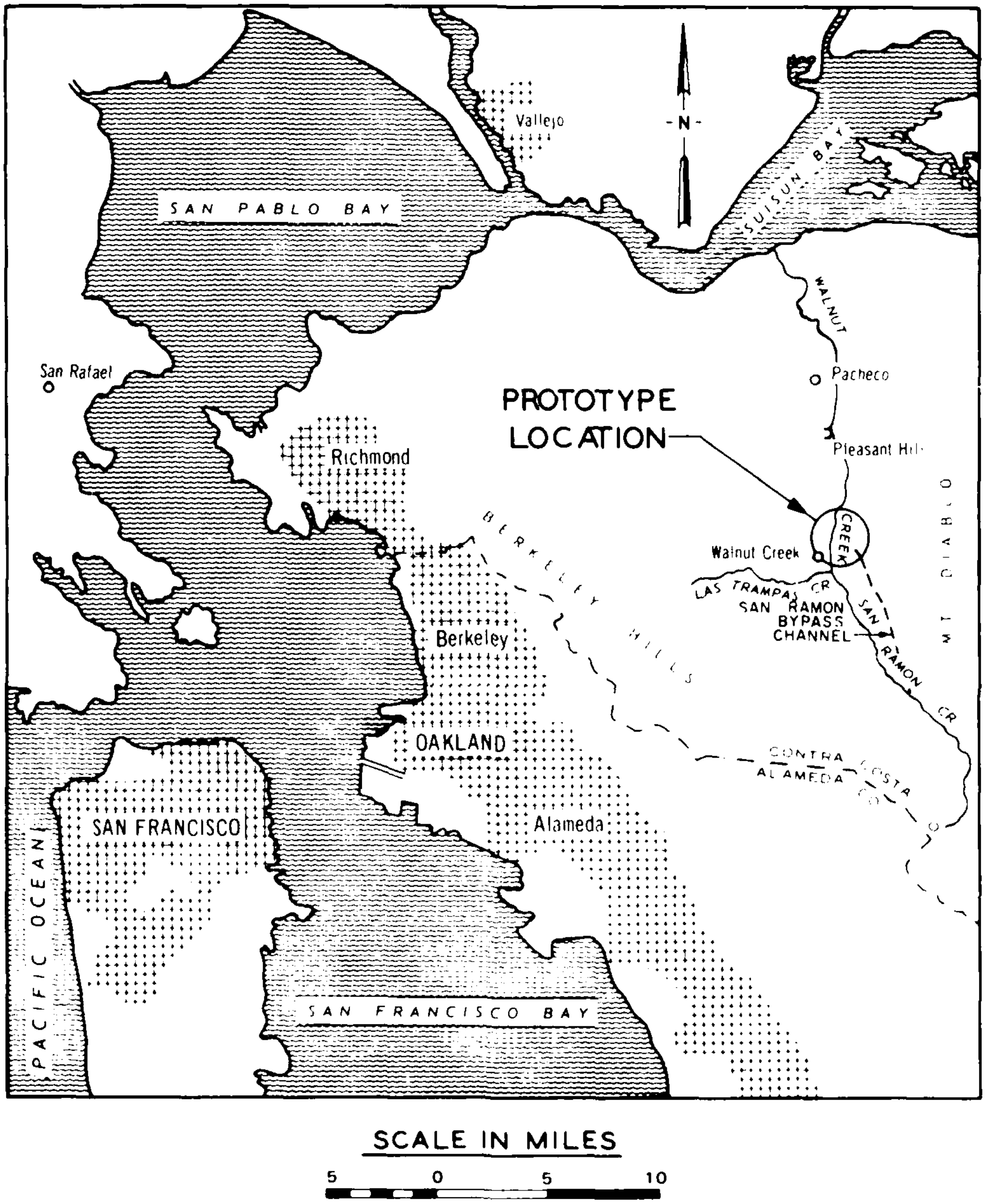

Figure 1. Vicinity map

WALNUT CREEK FLOOD-CONTROL PROJECT

CONTRA COSTA COUNTY, CALIFORNIA

Hydraulic Model Investigation

PART I: INTRODUCTION

The Prototype

1. The Walnut Creek Flood-Control Project is located 15 miles* east of San Francisco Bay in a depression between the Berkeley Hills and Mount Diablo (Figure 1). Walnut Creek flows in or near the cities of Walnut Creek, Concord, Pleasant Hill, and Martinez, California, on its way to the Suisun Bay. All of the planned improvements are located in Contra Costa County, California. The project was authorized in 1960 as a channel improvement project with earth- and rock-lined trapezoidal channels approved for the lower reaches of Walnut Creek and open concrete rectangular channels approved for the upper reaches of Walnut Creek and the San Ramon Bypass Channel through the highly urbanized area of the city of Walnut Creek. The project will provide flood protection to about 6,670 acres in the floodplain at and below the city of Walnut Creek.

2. The model study was concerned primarily with the proposed San Ramon Bypass Channel and its junction with the Walnut Creek channel in the city of Walnut Creek.

Purpose and Scope of Model Investigation

3. The purpose of the model investigation was to determine the adequacy of and develop desirable modifications to the proposed San Ramon Bypass Channel, the Walnut Creek-San Ramon junction, and the entrance to the revised Walnut Creek channel with design flow conditions. A physical model study of the system was desired because of the possibility of significant cross waves generated in curves and at the junction and turbulence at the junction and transitions. Specifically, the model study was to determine

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* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 3.

a. Flow conditions and water-surface profiles throughout the high-velocity channels for Manning's n roughness values of 0.012 and 0.014 during the following 100-year frequency flow conditions.

Waterway	Design Flow Upstream of Junction, cfs	Concurrent Flow, cfs	Combined Flow, cfs
Walnut Creek	10,000	11,500	21,500
San Ramon Bypass	15,200	6,800	22,000

b. Flow conditions resulting from expansions, contractions, and confluence.

c. Effective methods for modifying the channels to increase the hydraulic capacity and improve flow conditions.

PART II: THE MODEL

Description

4. The model, constructed to a scale of 1:25, reproduced approximately 1,084 ft of the San Ramon Bypass Channel, 730 ft of the Walnut Creek channel upstream from the junction, with topography reproduced upstream from the entrance to the revised channel, and 640 ft of the existing Walnut Creek channel downstream from the junction (Figure 2, Plates 1 and 2). The model was constructed of transparent plastic with the invert slopes adjustable to reproduce various energy gradients equivalent to those resulting from different prototype Manning's n roughness factors. Portions of the high-velocity channel requiring superelevation were constructed of concrete with a very smooth finish. The portion of Walnut Creek consisting of natural channel was molded in sand and cement mortar to sheet metal templates.

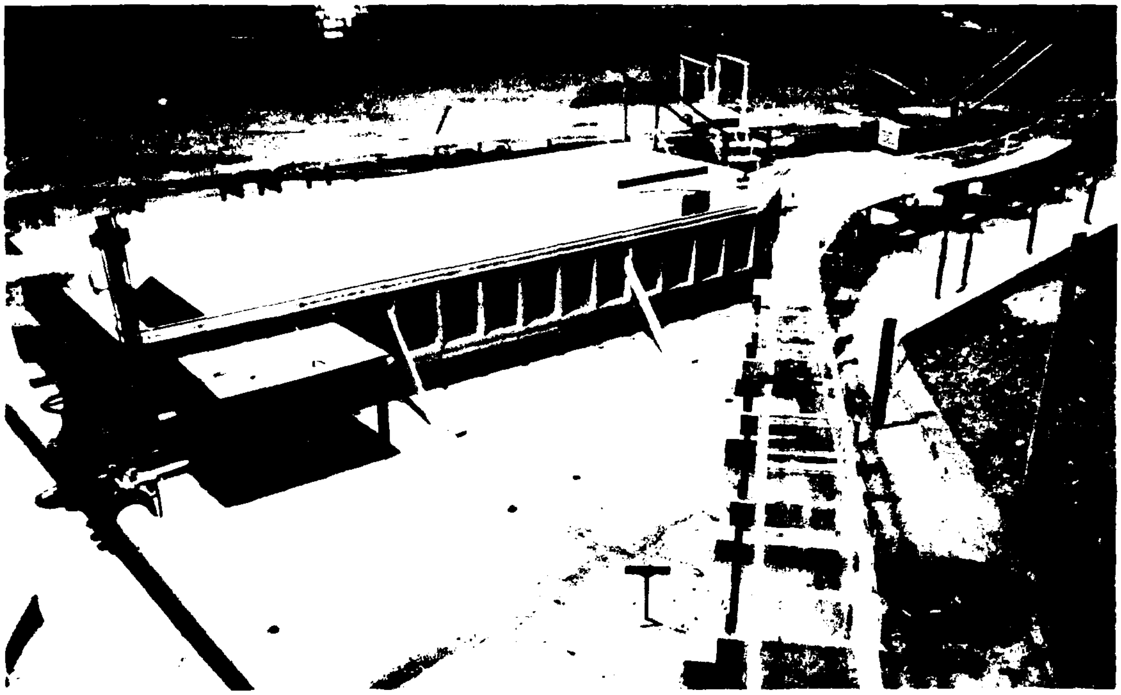
5. The coefficient of roughness of the model surface of the channels had previously been determined to be approximately 0.009 (Manning's n). Basing similitude on the Froudian relation, this n value would be equivalent to a prototype n of 0.0154. The n value used in the design and analysis of the prototype channels varied from 0.012 to 0.014; therefore supplementary slopes were added to the model to correct for this difference in the n values of the model and prototype.

Model Appurtenances

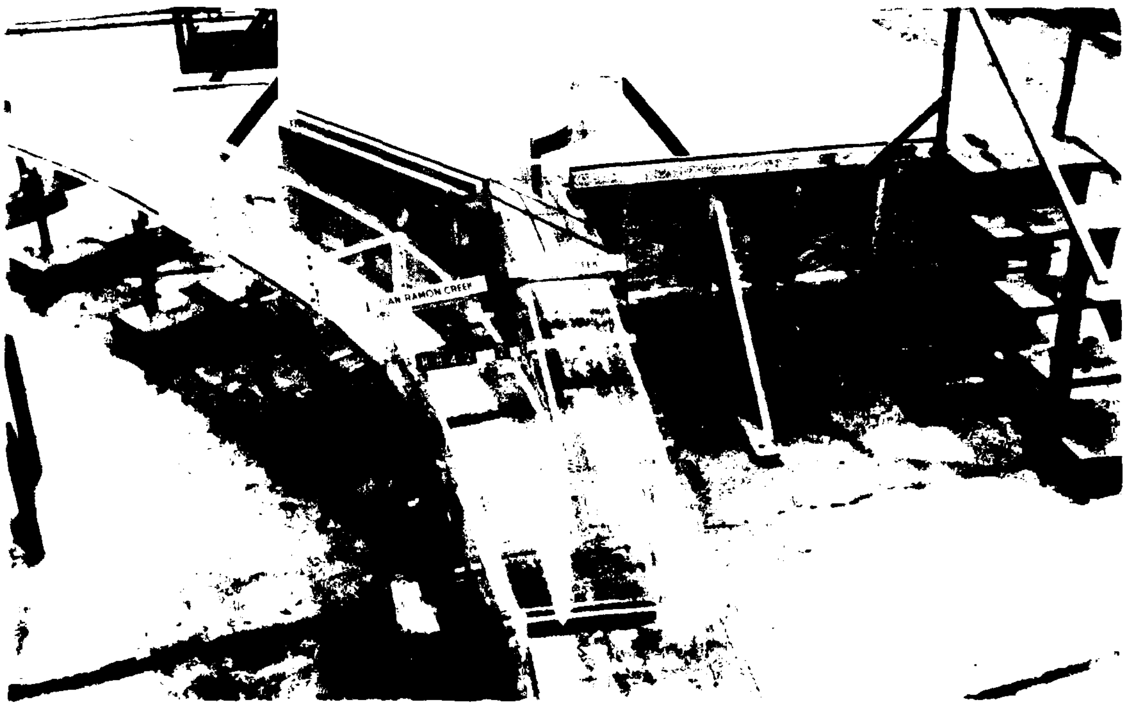
6. Water used in the operation of the model was supplied by a circulating system. Discharges were measured with venturi meters installed in the flow lines and were baffled when entering the model. Water-surface elevations were measured with point and rule gages. Different designs, along with various flow conditions, were recorded photographically.

Scale Relations

7. The accepted equations of hydraulic similitude, based on Froudian relations, were used to express mathematical relations between the dimensions and hydraulic quantities of the model and prototype. General relations for



a. General view



b. Closeup of Walnut Creek-San Ramon junction

Figure 2. The 1:25-scale model

transference of model data to prototype equivalents are as follows:

Characteristic	Dimension*	Model:Prototype
Length	$L_r = L$	1:25
Area	$A_r = L_r^2$	1:625
Velocity	$V_r = L_r^{1/2}$	1:5
Time	$T_r = L_r^{1/2}$	1:5
Discharge	$Q_r = L_r^{5/2}$	1:3,125
Roughness Coefficient	$N_r = L_r^{1/6}$	1:1.71

* Dimensions are in terms of length.

Model measurements of discharge and water-surface elevations can be transferred quantitatively to prototype equivalents by means of the preceding scale relations.

PART III: TESTS AND RESULTS

8. Tests were conducted to observe general flow conditions and determine the adequacy of the proposed channel improvements for the Walnut Creek channel and the proposed San Ramon Bypass Channel. The Manning's n roughness coefficient of the prototype channels could range from 0.012 to 0.014 depending on the quality of construction.

Initial Tests (n = 0.012)

9. The invert slopes of the channels initially tested were adjusted to reproduce an energy gradient resulting from a Manning's n roughness factor of 0.012 in the prototype. Representatives from Office, Chief of Engineers (OCE), US Army, US Army Engineer Division, South Pacific, and US Army Engineer District, Sacramento, inspected the model and observed test runs on 31 January 1984. It was agreed that certain modifications to the model were needed before basic data such as water-surface profiles and photographs of flow conditions were recorded. These modifications included raising the walls near the inlet to the high-velocity channel on Walnut Creek (Plate 3) and placing a low weir in this area. The original design defined herein includes these changes. Water-surface profiles recorded for the 100-year frequency flow Q_{100} conditions in both Walnut Creek and the San Ramon Bypass Channel with the respective maximum concurrent flows are shown in Plates 4 and 5. These flow conditions are shown in Photos 1-6. The black lines shown on the walls of the channels are the proposed wall heights.

10. Satisfactory flow conditions were observed in Walnut Creek upstream from the junction with San Ramon Bypass Channel with discharges less than 7,000 cfs. When the discharge was increased to 7,000 cfs and greater, flow began to enter the channel through the access ramp (Photo 4c). This created unsatisfactory flow conditions which included standing waves that extended downstream to the junction.

11. At the upstream end of the concrete channel in Walnut Creek, a wall was installed which bridged the access ramp (Photo 7a, Plate [illegible]) in an effort to improve flow conditions with discharges greater than 7,000 cfs. With this modification, flow conditions were significantly improved in the portion of Walnut Creek upstream from the junction with discharges greater than 7,000 cfs.

Water-surface profiles recorded with the 100-year frequency discharge in Walnut Creek of 10,000 cfs and the maximum concurrent discharge in the San Ramon Bypass Channel are shown in Plate 7. Flow conditions with this modification are shown in Photos 7b and 8.

12. Flow did not exceed the wall heights in the San Ramon Bypass Channel for any discharge observed. However, standing waves developed downstream from sta 586+50 which extended several hundred feet downstream for all discharges observed. These waves were caused, in part, by the channel alignment, which involved a 75-ft straight reach of channel positioned between two curved sections from sta 586+62.58 to sta 582+49.55.

13. Flow exceeded the wall heights at several points downstream from the San Ramon-Walnut Creek junction for both design flows with their maximum concurrent flows (Plates 4 and 5). Various divider wall extensions were tested in an effort to reduce the standing waves that developed downstream of the junction. Initially, a 10-ft-long extension was added to the divider wall. This extension changed the profiles in Walnut Creek somewhat, but water-surface elevations on the right wall exceeded the wall heights by 2 to 3 ft in two places. The divider was then extended 30 ft. This extension constricted flow in the Walnut Creek channel with the design flow in San Ramon Creek and a concurrent flow of 6,800 cfs in Walnut Creek and caused a hydraulic jump to form upstream from the divider. However, the waves downstream from the divider were reduced, and the wall heights were occasionally exceeded by only 1 ft in a few places. The wall was extended 63.8 ft to sta 581+75.8 where the existing Walnut Creek channel is 40 ft wide. This extension further constricted flow in the Walnut Creek channel and caused the hydraulic jump to move upstream from the divider and overtop the walls. In an effort to reduce the constriction of flow in the Walnut Creek channel, various alignments of the 63.8-ft-long extension were tested. The best alignment was with the nose of the divider 21.25 ft from the left wall. However, the hydraulic jump still formed about 175 ft upstream from the divider, and there was slight overtopping of the walls. The wall extension length was reduced to 40 ft. Of the various alignments tested with this wall, the wall centered in the channel was found to be optimum. Although flow was restricted in the Walnut Creek channel and a hydraulic jump formed upstream from the divider with the design flow of 15,200 cfs in San Ramon Creek and the concurrent flow of 6,800 cfs in Walnut Creek, flow did not overtop the walls. With the design flow of 10,000 cfs in

Walnut Creek and the concurrent flow of 11,500 cfs in San Ramon Creek, there was an occasional splashover of flow at sta 581+20, but this was insignificant. Flow conditions were greatly improved in the channel downstream from the divider. The 40-ft-long divider extension was determined to be the optimum length with a Manning's n value of 0.012. Water-surface profiles with various divider extensions are shown in Plates 8-17. Flow conditions are shown in Photos 9-18.

Increased Roughness (n = 0.014)

14. The slopes of the model were adjusted to reproduce the energy gradient for a roughness value (Manning's n) of 0.014. These tests were conducted with the channel improvements installed that were recommended from previous tests conducted with the channel invert slopes adjusted to reproduce a Manning's n roughness factor of 0.012. These improvements included a wall that bridged the access ramp in Walnut Creek and a 40-ft-long divider extension at the San Ramon-Walnut Creek junction.

15. Water-surface profiles recorded for the 100-year frequency flow conditions in both Walnut Creek and San Ramon Bypass Channels with respective maximum concurrent flows are shown in Plates 18 and 19. Flow conditions are shown in Photos 19 and 20.

16. Flow did not exceed the wall heights in the San Ramon Bypass Channel for any of the discharges tested. With the design flow of 15,200 cfs in the San Ramon Bypass Channel and a concurrent flow of 6,800 cfs in Walnut Creek, a hydraulic jump formed in the Walnut Creek channel upstream from the junction which occasionally overtopped the existing wall heights. Flow occasionally exceeded the wall heights by 1 to 2 ft at sta 581+65, as shown in Plate 18 and Photo 19b.

17. With the design flow of 10,000 cfs in Walnut Creek and a concurrent flow of 11,500 cfs in the San Ramon Bypass Channel, flow exceeded the wall heights by only 1 ft in a few places, but overtopped the walls by as much as 5 ft from sta 577+85 to sta 579+10, as shown in Plate 19 and Photo 20a.

18. Additional channel improvements were needed to reduce the excessive overtopping of the channel walls. These channel improvements, designated the type 2 design channel, included decreasing the width of the San Ramon Bypass Channel from 24 to 23 ft from sta 587+70 to sta 582+24.37, improving the

channel alignment at the junction (Plate 20), adjusting the invert slope in the Walnut Creek channel to 0.005 ft/ft from sta 582+37.37 to sta 576+00 (this slope was maintained in the San Ramon Bypass Channel from the junction with Walnut Creek upstream to sta 584+98), and adjusting the invert slope in the Walnut Creek channel to 0.0185 ft/ft from sta 584+50 to sta 582+37.37.

19. Water-surface profiles measured with the type 2 design channel for the 100-year frequency flow conditions in both Walnut Creek and the San Ramon Bypass Channels with respective maximum concurrent flows are shown in Plates 21 and 22. These flow conditions are shown in Photo 21. Satisfactory flow conditions were observed in the San Ramon Bypass Channel for all discharges tested. With the design flow of 15,200 cfs in the San Ramon Bypass Channel and a concurrent flow of 6,800 cfs in Walnut Creek, a hydraulic jump formed in the Walnut Creek channel upstream from the junction which occasionally overtopped the wall by 1 to 2 ft between sta 583+20 and 581+50, as shown in Plate 21 and Photo 21b. With the design flow of 10,000 cfs in Walnut Creek and a concurrent flow of 11,500 cfs in the San Ramon Bypass Channel, flow exceeded the wall heights by 1.5 ft maximum at sta 581+20, as shown in Plate 22 and Photo 21a.

20. The previous modification, which involved steeper slopes in Walnut Creek, resulted in the invert of the entrance to the concrete channel being increased from el 104* to el 105.5. This increase in elevation caused an increase in the upstream pool elevation. Tests were conducted to determine modifications, which did not include widening the channel, that would reduce the upstream pool elevation without affecting flow conditions at and downstream of the junction.

21. In an effort to improve the entrance conditions in the Walnut Creek channel, the access ramp was completely blocked off and the upstream face of the channel invert was sloped downward. This design resulted in a reduction in the upstream pool elevation from el 133.5 to el 132.7 for the 100-year frequency flow, as shown in Plate 23. The left side was then modified to simulate a symmetrical entrance approach to the channel (Plate 24, Photo 22a). Test results indicated the upstream pool elevation was lowered to el 132.6 for the 100-year frequency flow with this modification. Water-surface profiles

* All elevations (el) and stages cited herein are in feet referred to the National Geodetic Vertical Datum.

and photographs of flow conditions in the approach channel are shown in Plate 25 and Photo 22, respectively. Since the streamlined left wall entrance decreased the water surface only by 0.1 ft, and would involve major structural modifications, it would not be feasible to incorporate this modification into the design.

Recommended Design

22. The overall recommended design determined from test results for a Manning's n of 0.012 incorporates into the original proposed design raising the walls near the inlet to the high-velocity channel on Walnut Creek (Plate 3), bridging the access ramp (Plate 6), and lengthening the divider extension to 40 ft.

23. The overall recommended design determined from test results for a Manning's n of 0.014 incorporates into the original proposed design raising the walls near the inlet to the high-velocity channel on Walnut Creek (Plate 3), bridging and blocking off the access ramp (Plate 6), increasing the invert slope in the Walnut Creek channel to 0.0185 ft/ft from sta 584+50 to sta 582+37.37, decreasing the width of the San Ramon Bypass Channel from 24 to 23 ft (Plate 20), improving the channel alignment at the junction, increasing the slope in the Walnut Creek channel to 0.005 ft/ft downstream from the junction to sta 576+00, and lengthening the divider extension to 40 ft.

PART IV: SUMMARY AND CONCLUSIONS

24. Tests to determine the adequacy of channel improvements for Walnut Creek indicated that the original design with certain modifications would effectively contain design flow conditions in the Walnut Creek channel improvement project.

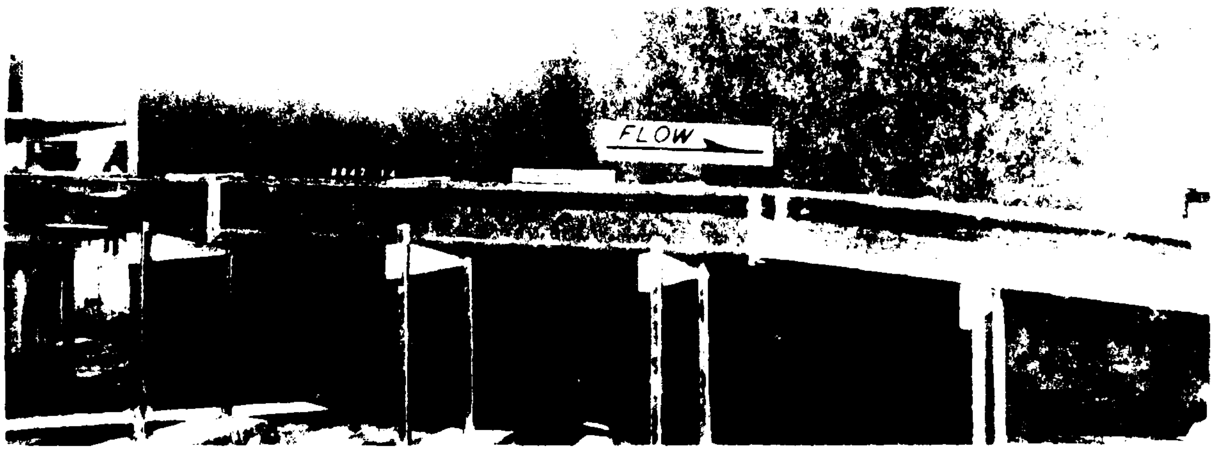
25. It was anticipated that the Manning's n roughness coefficient of the prototype concrete-lined channel could range from 0.012 to 0.014, depending on the quality of construction. Water-surface elevations would be slightly higher with the larger n value, and flow velocities and waves created by disturbances would be slightly higher with the smaller n value. Thus, tests were conducted to simulate the energy gradient resulting from both of the n values.

26. With a Manning's n value of 0.012 reproduced, entrance conditions into the high-velocity channel on Walnut Creek caused standing waves to develop that extended downstream to the junction due to unsymmetrical approach and inflow into the channel through the access ramp. By blocking off the access ramp, flow conditions and channel efficiency were significantly improved.

27. Flow did not exceed the wall heights in the San Ramon Bypass Channel for the design discharges. However, standing waves developed downstream from sta 586+50 that may have been caused by the channel alignment, which involved a 75-ft straight reach of channel positioned between two curved sections. Flow exceeded the wall heights at several points downstream from the junction for both design flows. A 40-ft-long divider extension greatly improved flow conditions and alleviated overtopping of the walls.

28. The slopes of the Walnut Creek and San Ramon Bypass Channels were adjusted to reproduce the energy gradient for a roughness value of 0.014. This increase in roughness caused overtopping of the wall heights in the Walnut Creek channel for both design discharges. A new section of channel was installed on the San Ramon Bypass which reduced the channel width from 24 to 23 ft and improved the channel alignment at the junction. The invert slope in the Walnut Creek channel was increased to 0.005 ft/ft downstream from the junction and was increased to 0.0185 ft/ft upstream from the junction. With these modifications installed, both design flow conditions were adequately contained in the channels.

a. Dry bed

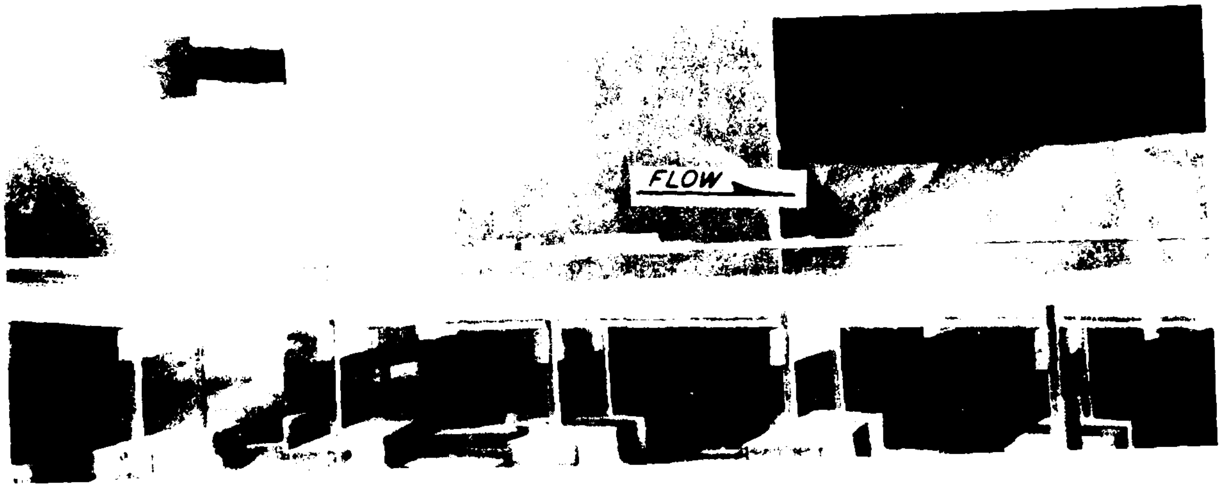


b. Discharge 11,[illegible]00 cfs

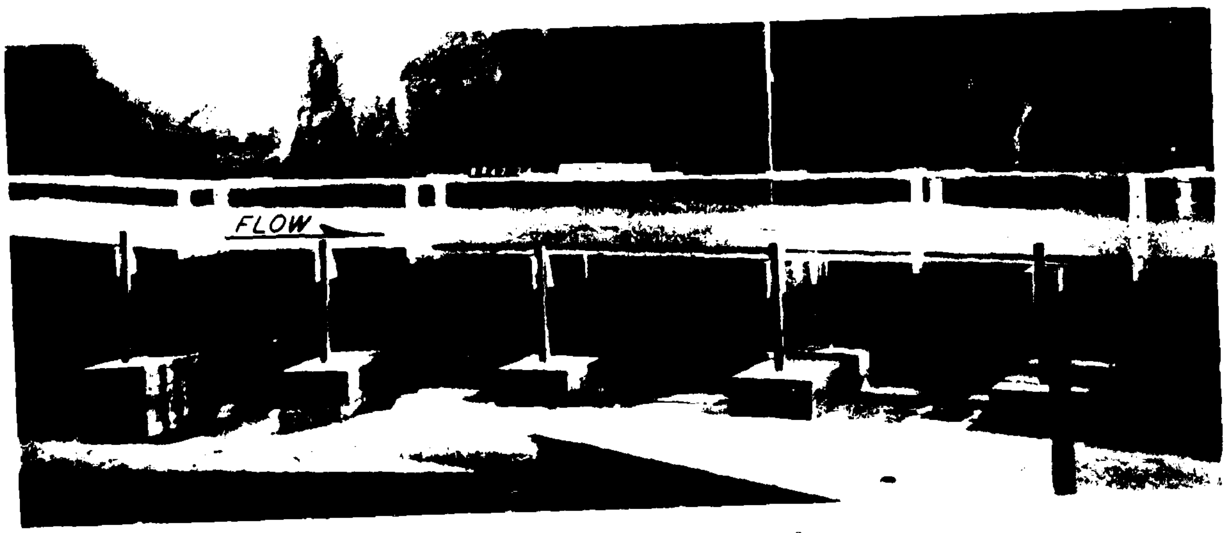
[illegible]

[illegible]

a. Dry bed

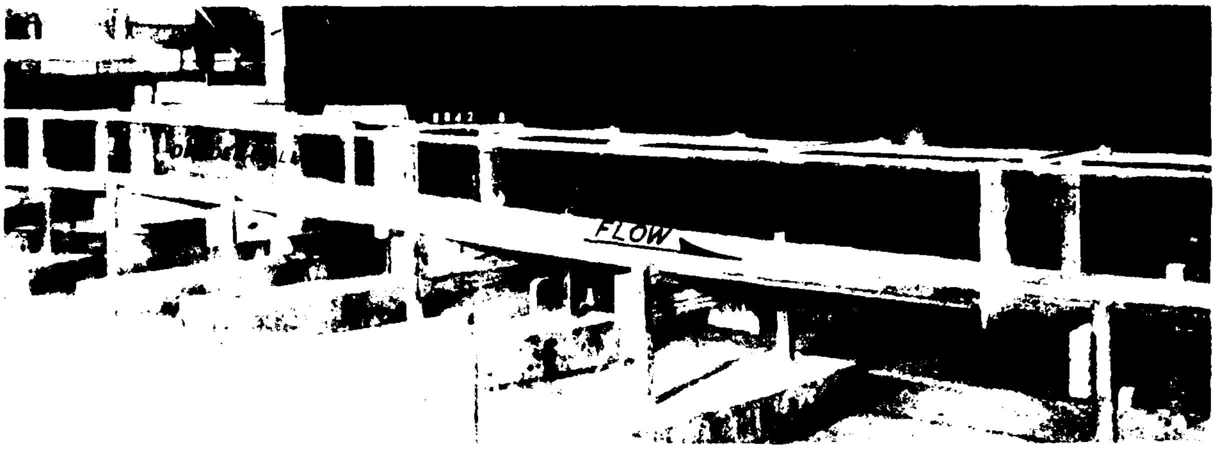


b. Discharge 11,500 cfs



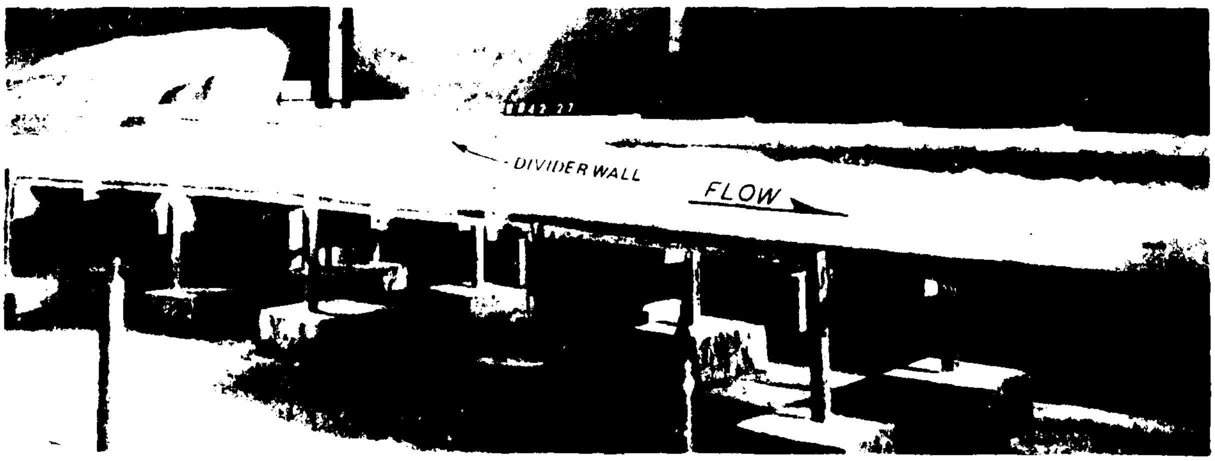
c. Discharge 1[illegible] cfs

Photo [illegible]. San Ramon Bypass Channel, looking [illegible] the right side of the channel between sta [illegible]



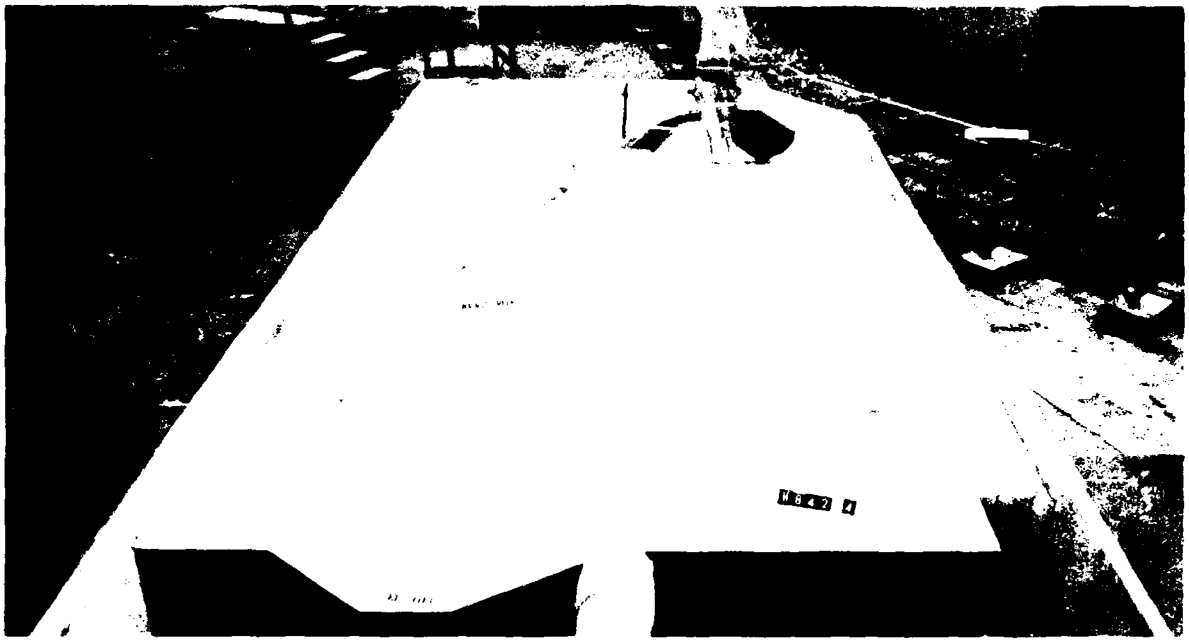
a. Dry bed

b. Discharge 11,500 cfs in San Ramon
Discharge 10,000 cfs in Walnut Creek



c. Discharge 15,[illegible]00 cfs in San Ramon
Discharge [illegible],800 cfs in Walnut Creek

[illegible] San Ramon Bypass Channel-Walnut Creek junction, looking [illegible]



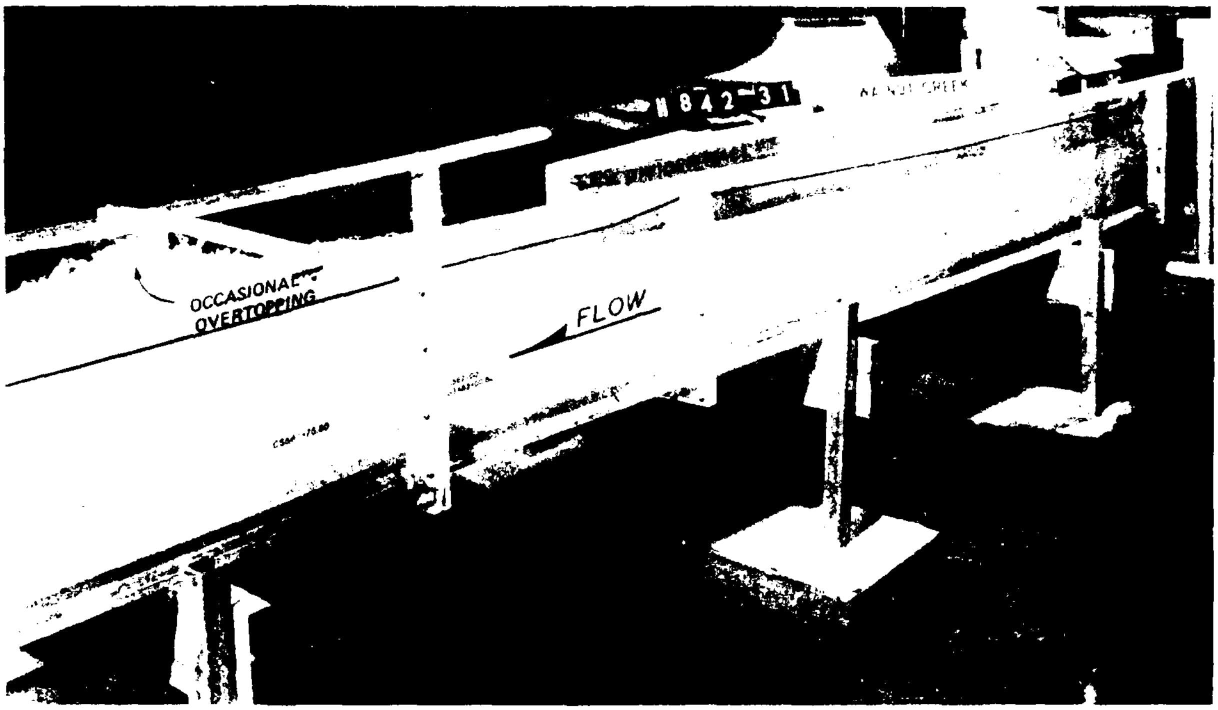
a. Dry bed

b. [illegible]

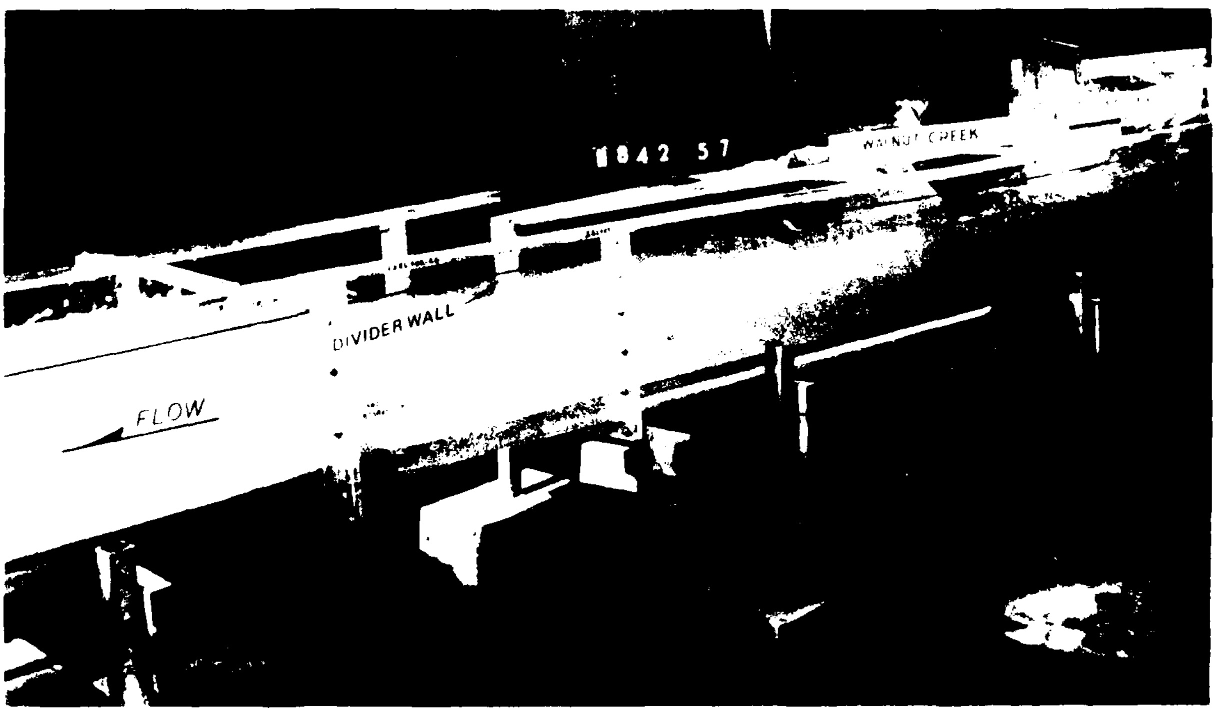
Photo 4. Walnut Creek, looking downstream at the [illegible] velocity channel, [illegible]

c. Discharge 10,000 cfs

Photo 4. (Concluded)

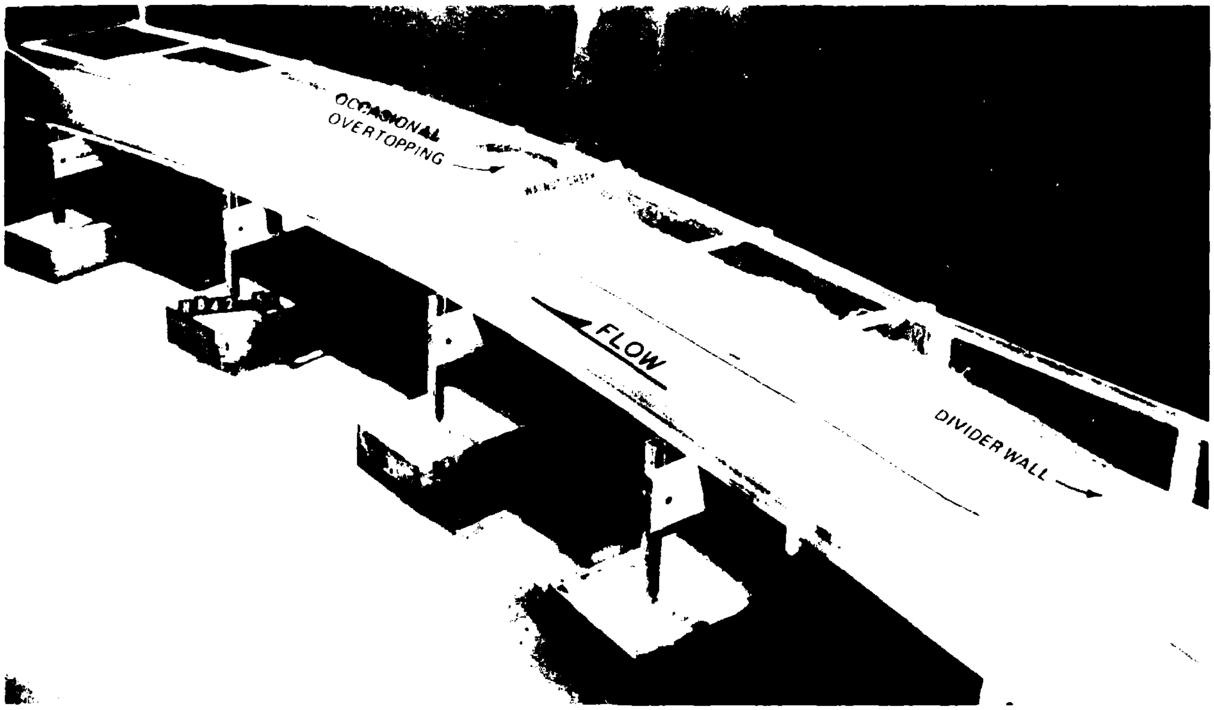


a. Discharge 6,800 cfs in Walnut Creek
Discharge 15,200 cfs in San Ramon

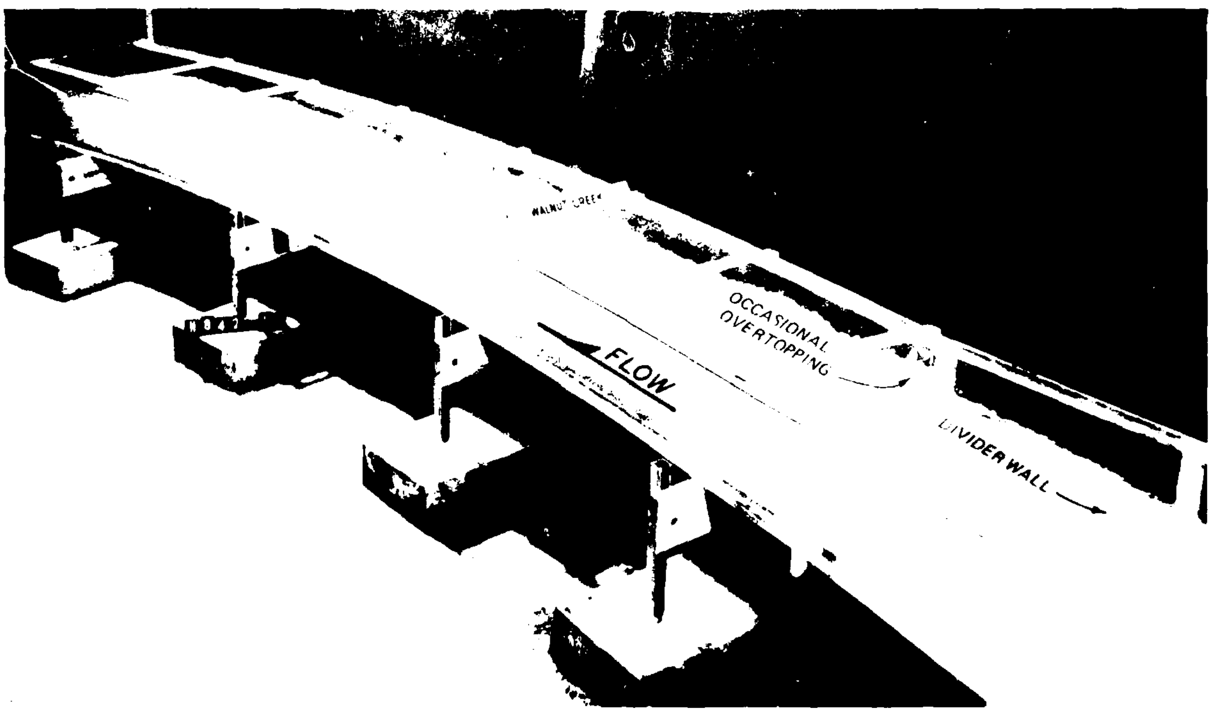


b. Discharge [illegible] cfs in Walnut Creek
Discharge 11,[illegible] cfs in San Ramon

[illegible]

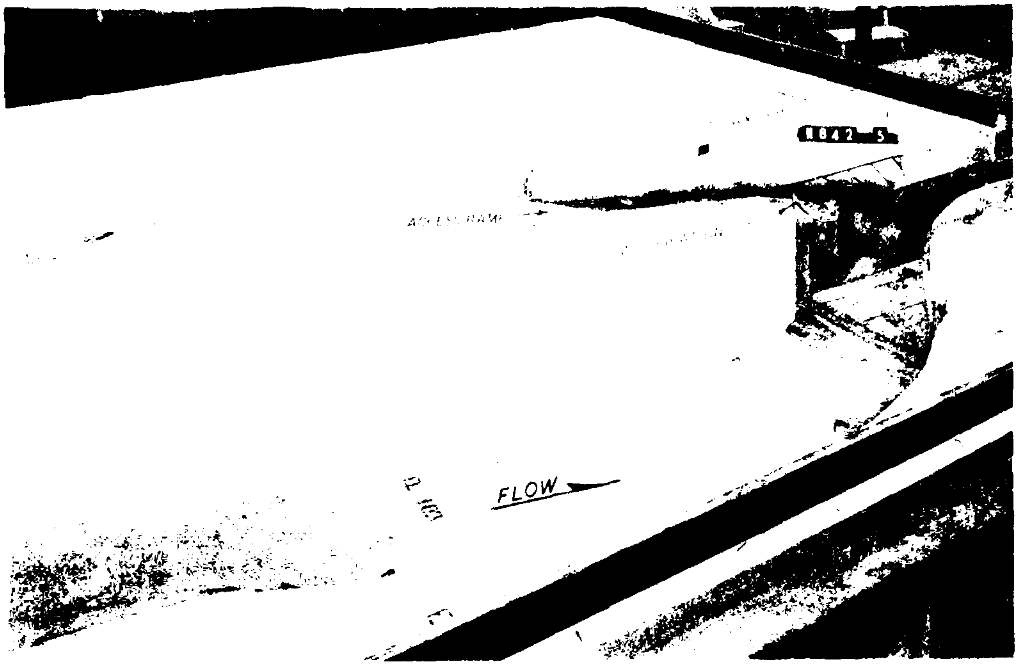


a. Discharge 21,500 cfs



b. Discharge [illegible] cfs

Photo [illegible]. Walnut Creek, [illegible]
[illegible]



a. Dry bed

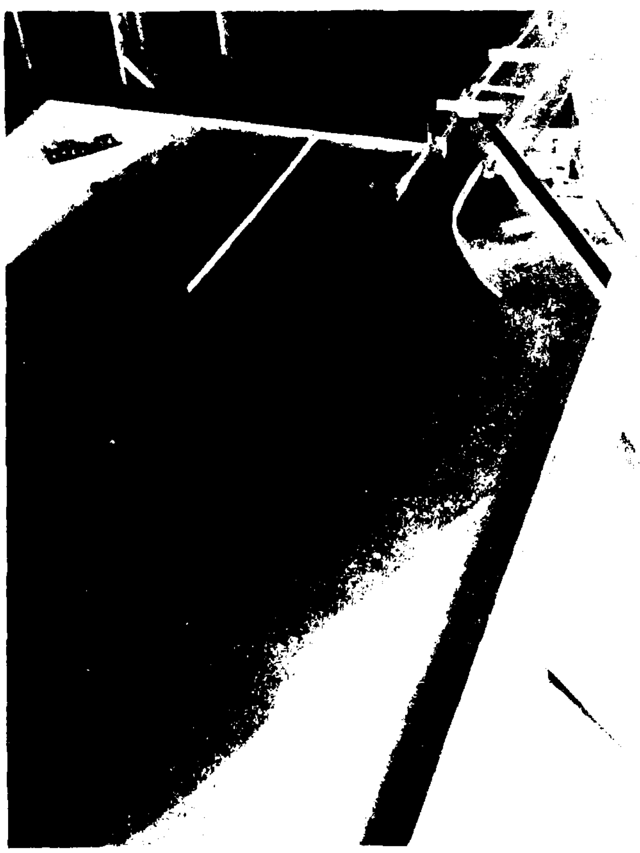
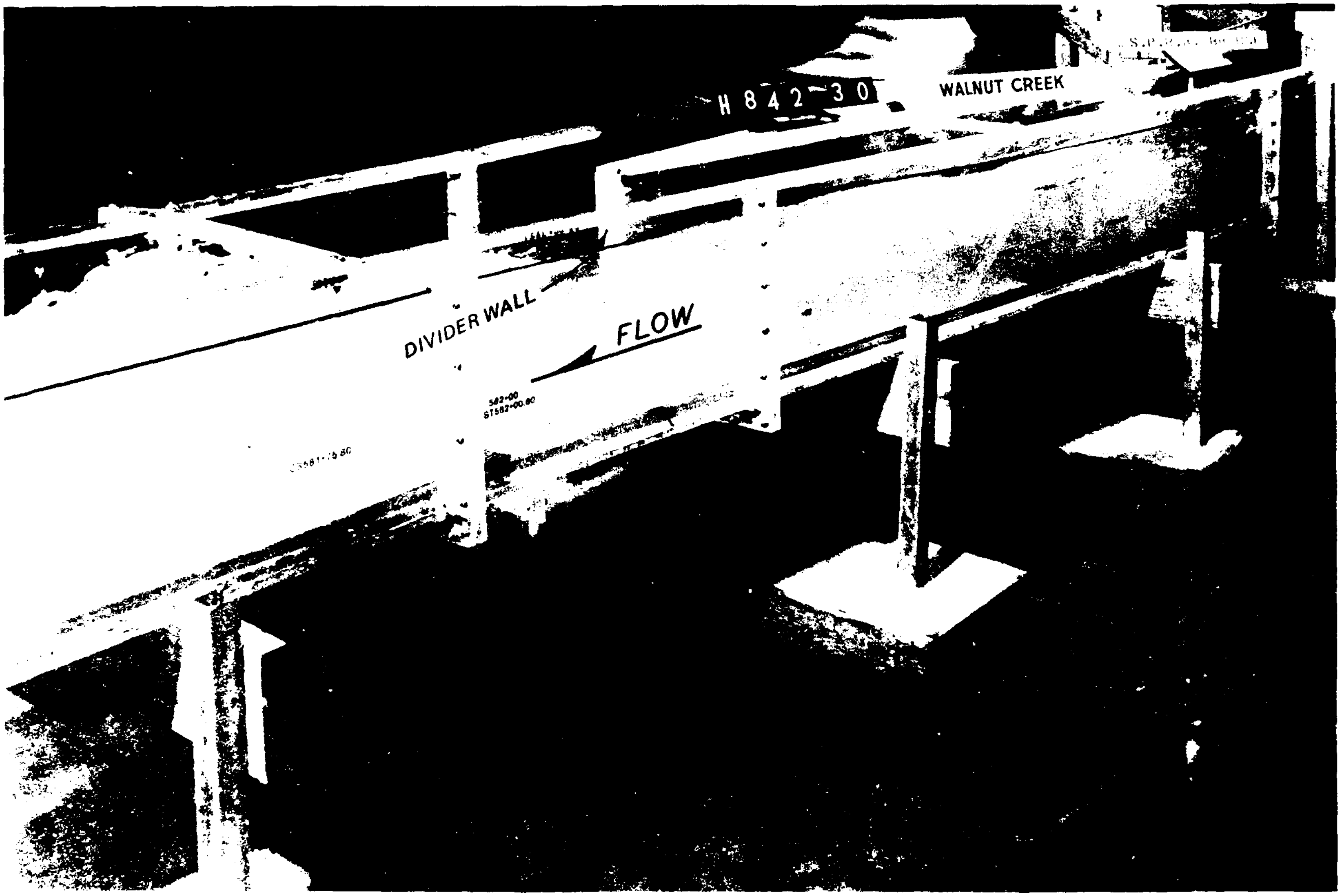
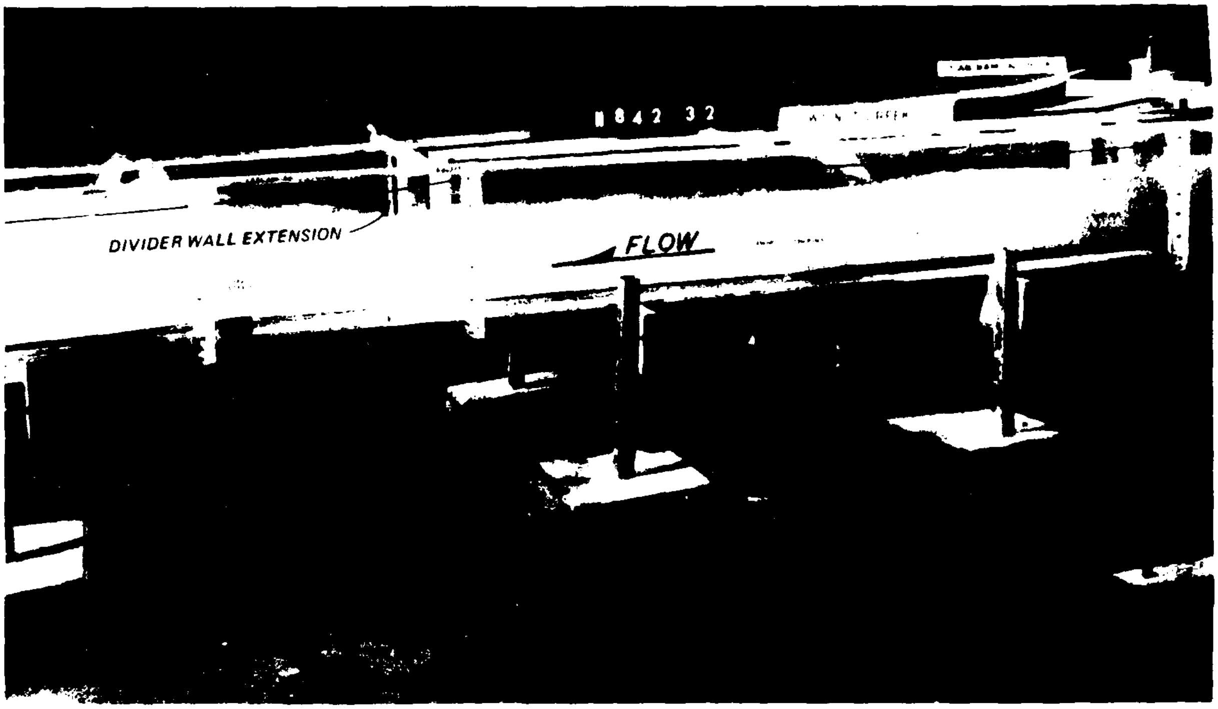


Photo 7. Walnut Creek,

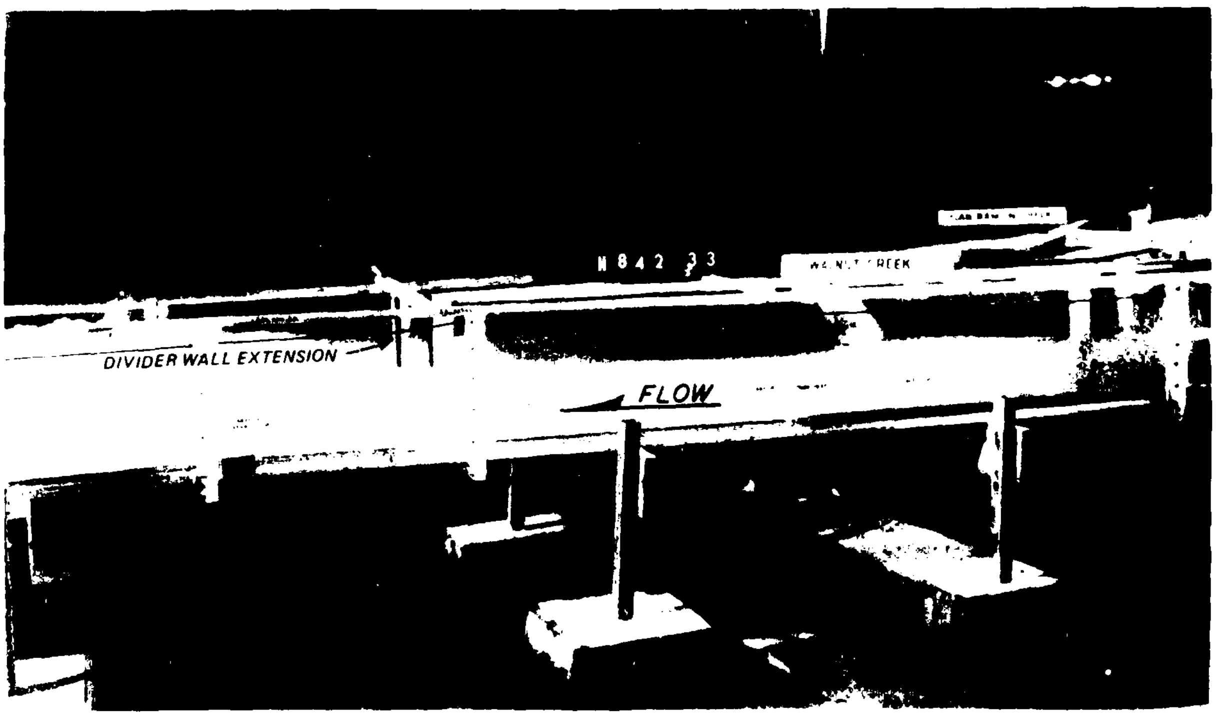
high-velocity



[illegible]. Walnut Creek-San Ramon Bypass Channel junction, looking upstream in the left side of the channel, access ramp bridged, n = 0.012. Discharge 10,000 cfs in Walnut Creek

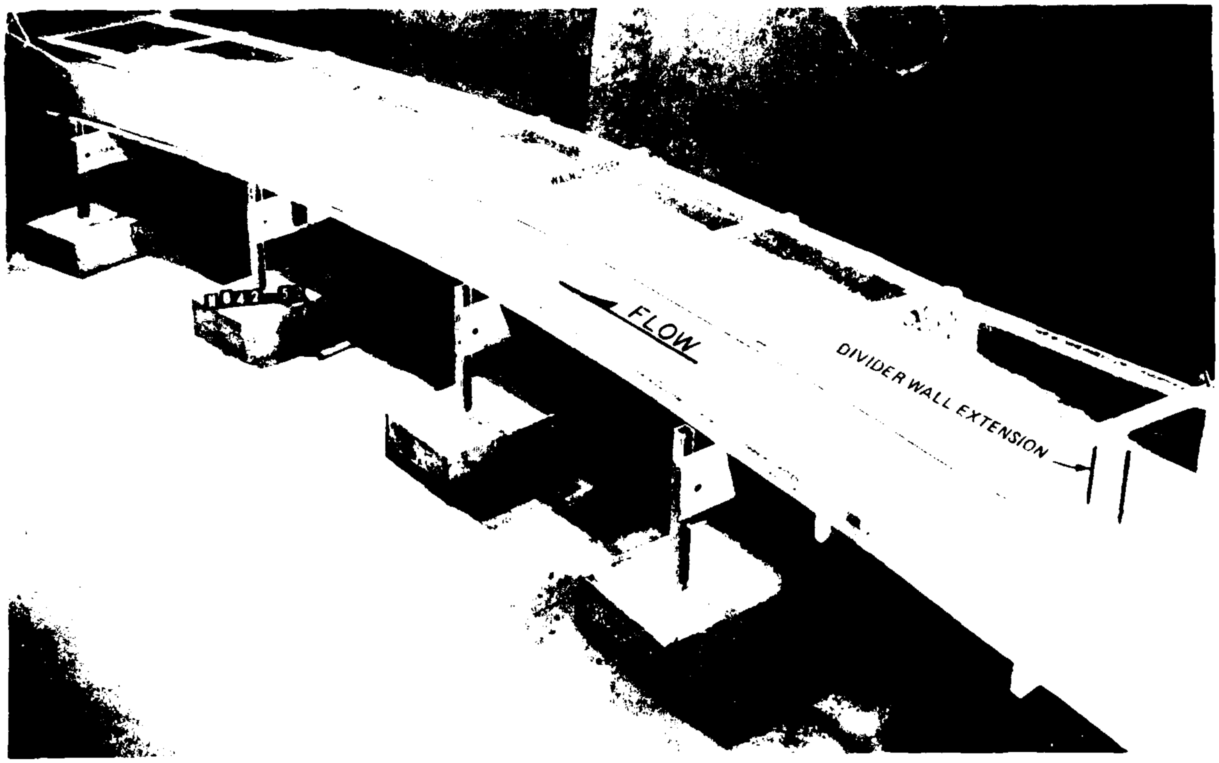


a. Discharge 21,500 cfs

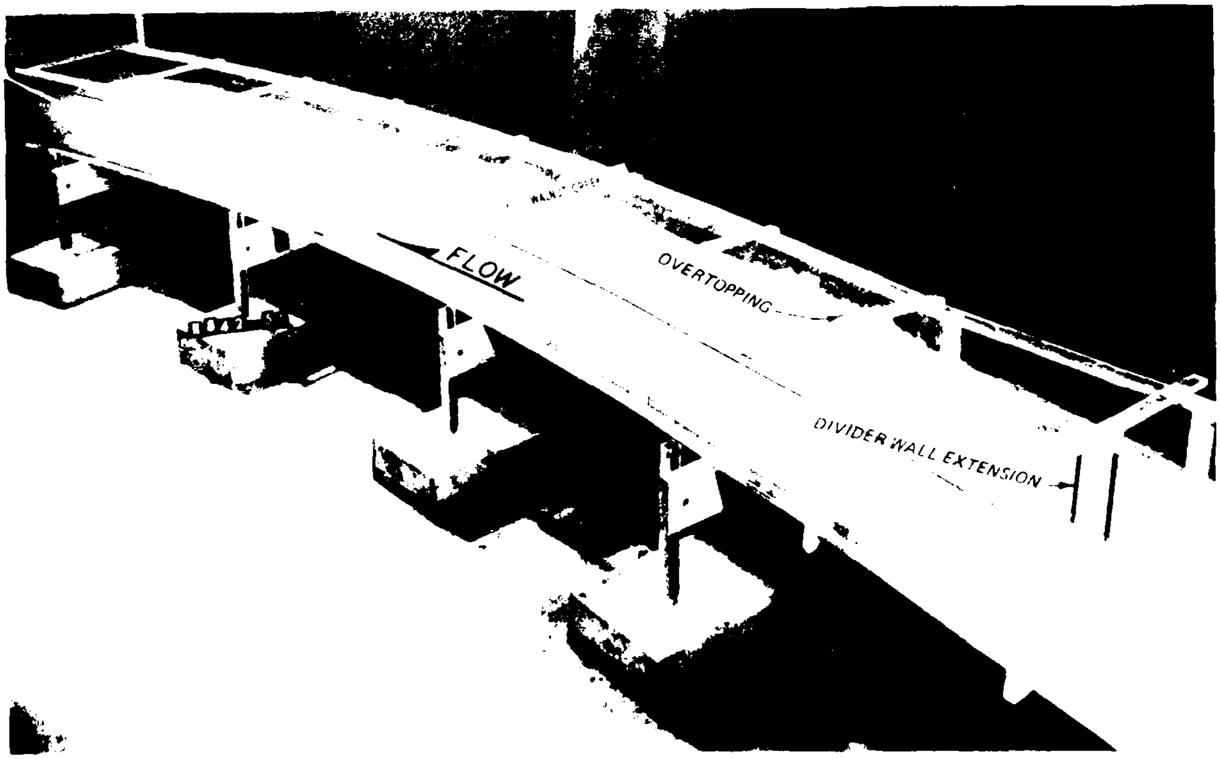


b. Discharge [illegible],000 cfs

Photo 9. Walnut Creek-San Ramon Bypass Channel junction, looking in the left side of the channel with the 10-ft divider extension installed, [illegible]

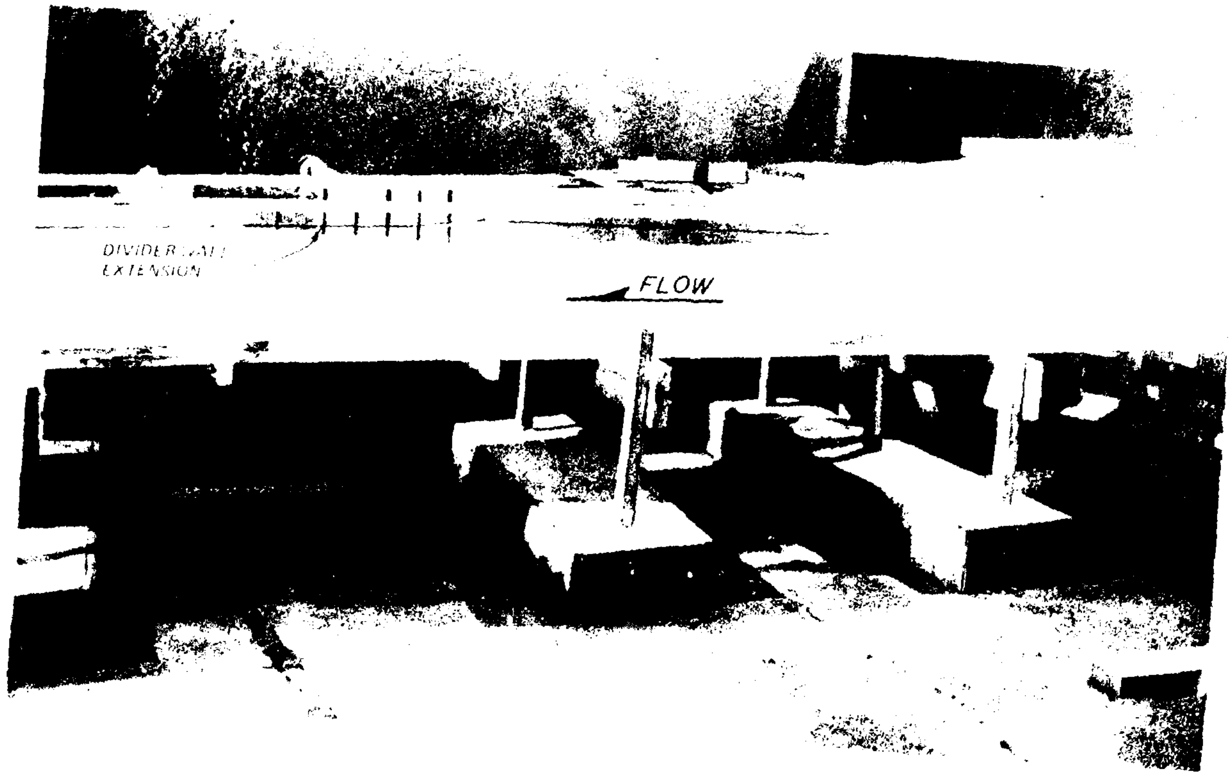


a. Discharge 21,500 cfs

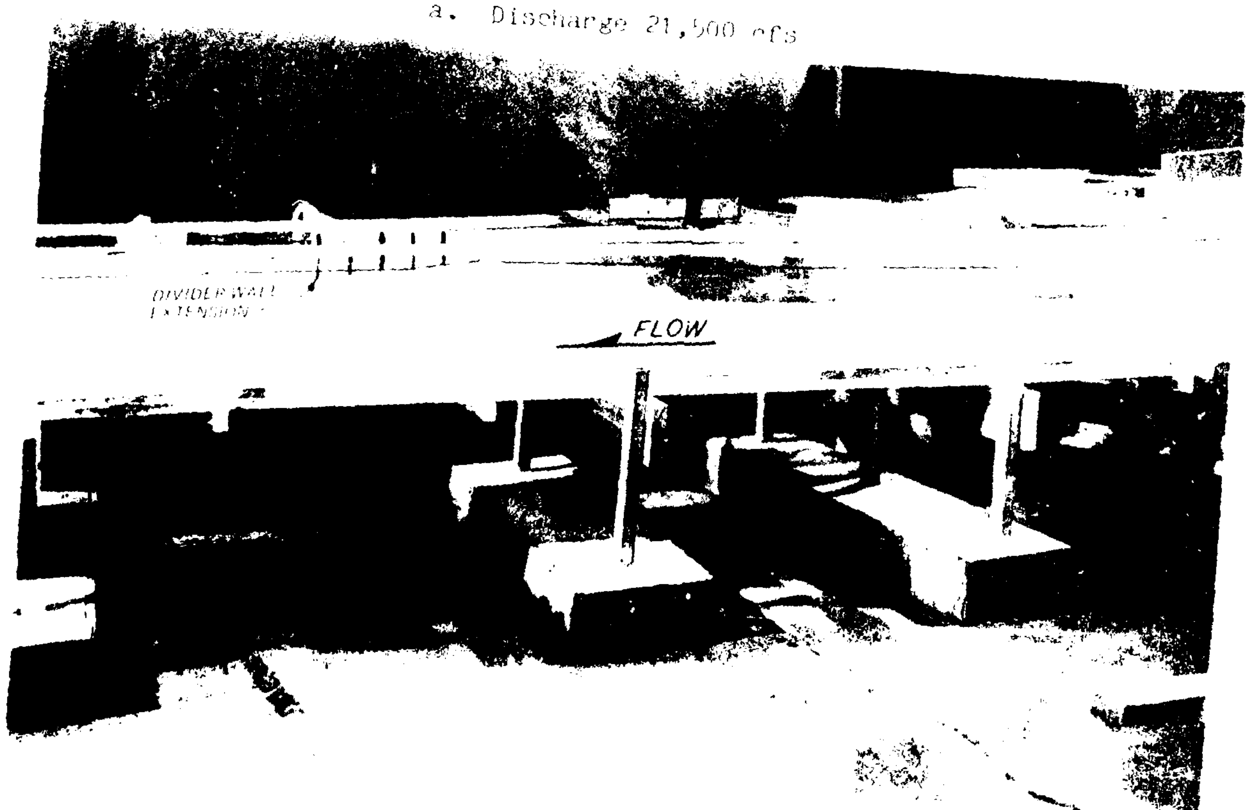


b. Discharge [illegible],000 cfs

[illegible]. Walnut Creek, looking downstream in the left side of the channel between [illegible] and [illegible]+00 with the 10-ft divider extension installed, n = [illegible]

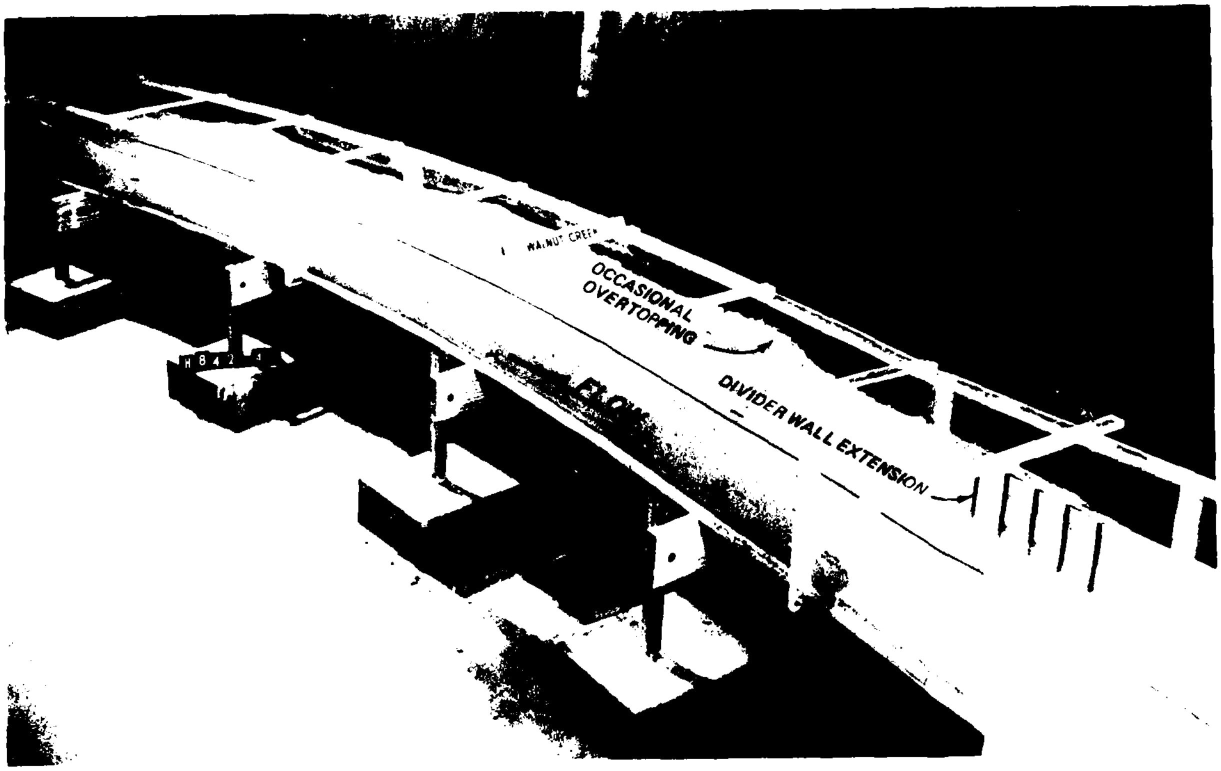


a. Discharge 21,500 cfs

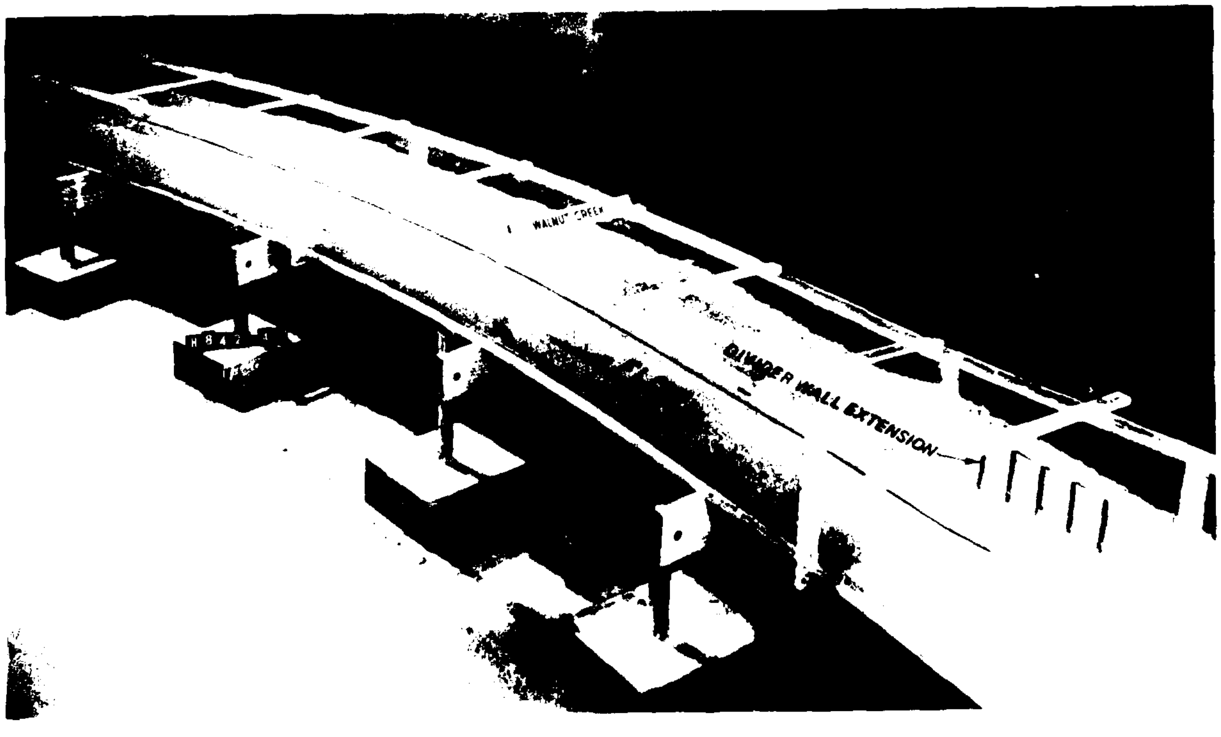


b. Discharge [illegible]

Photo 11. Walnut [illegible]
side of the channel with the [illegible]

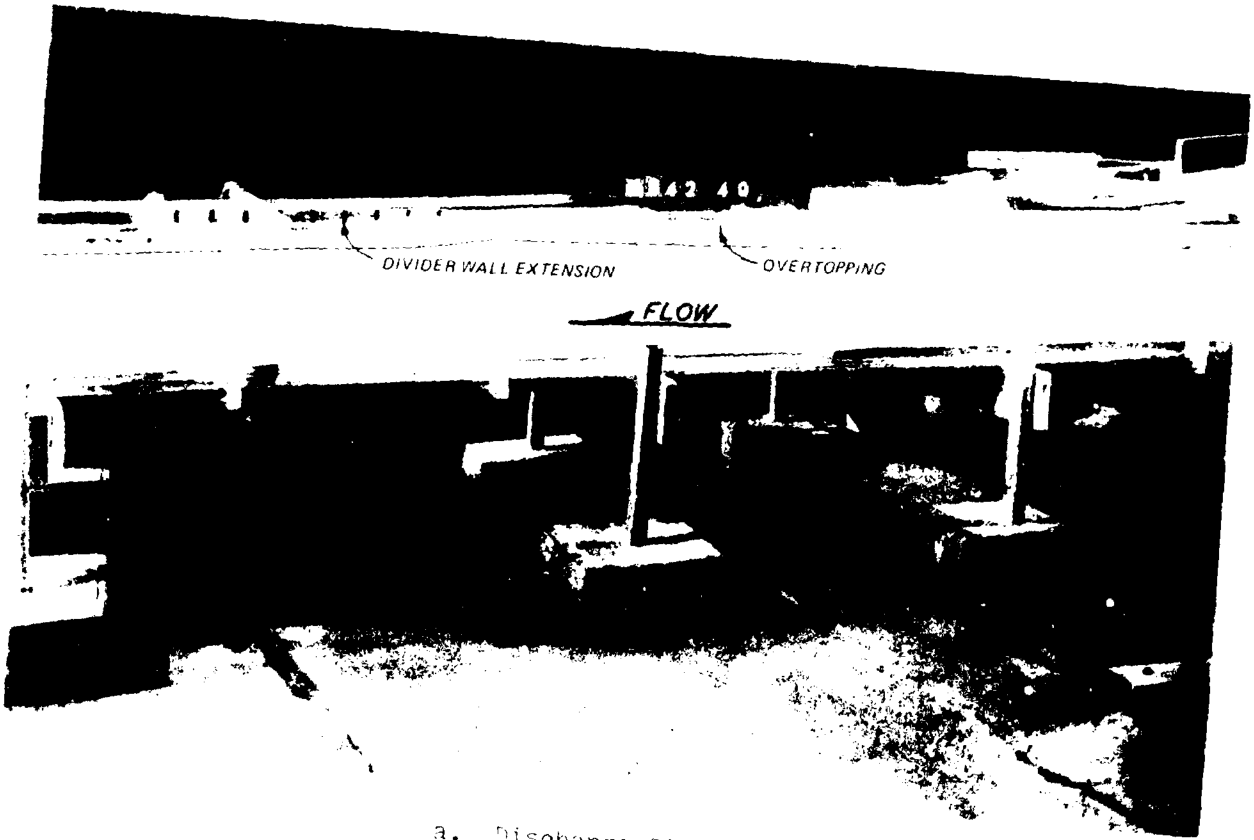


a. Discharge 21,500 cfs

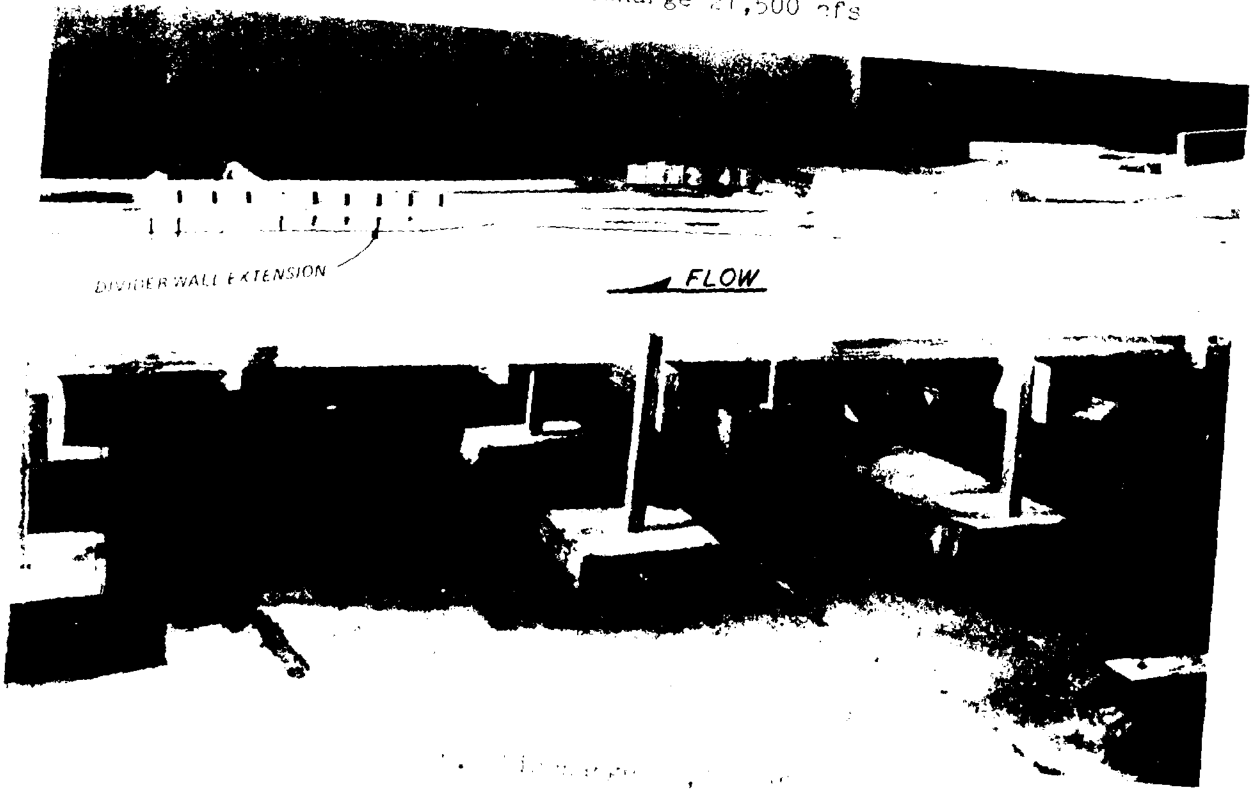


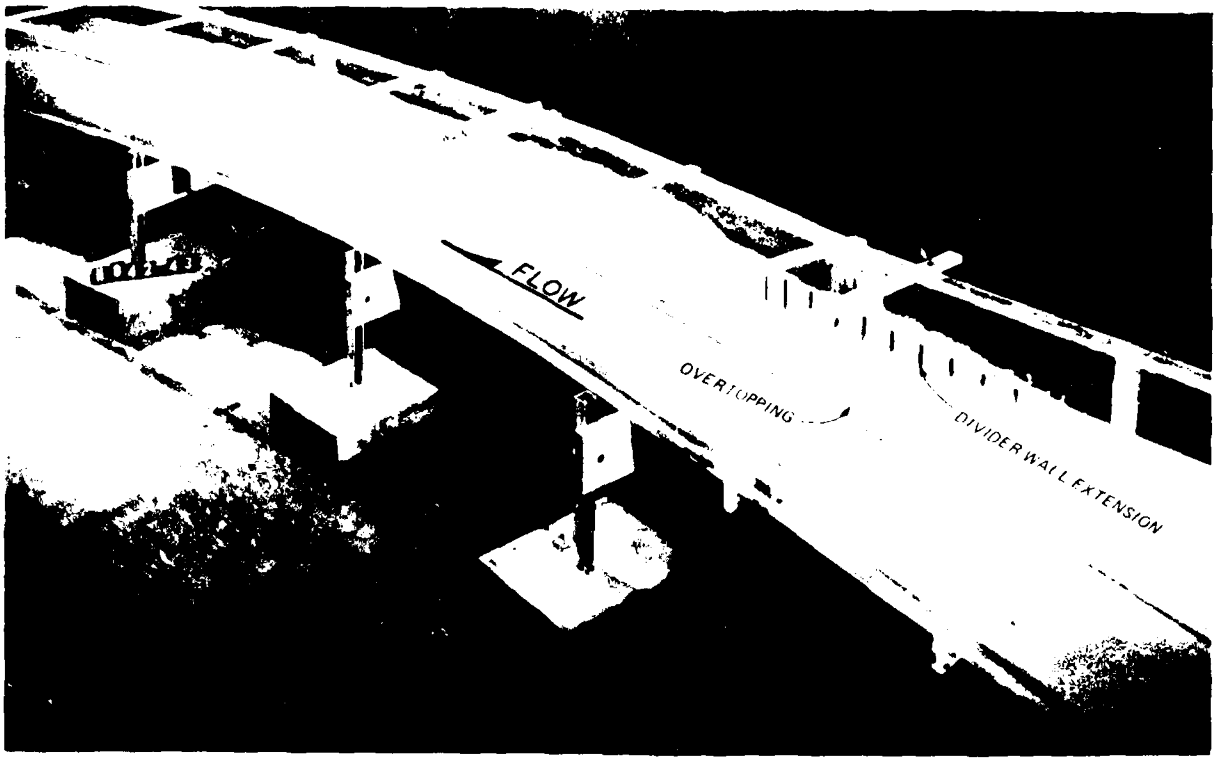
b. Discharge 22,000 cfs

Photo 12. Walnut Creek, looking downstream in the left side of the channel between sta 582+50 and 578+00 with the 30-ft divider extension installed, n = 0.012

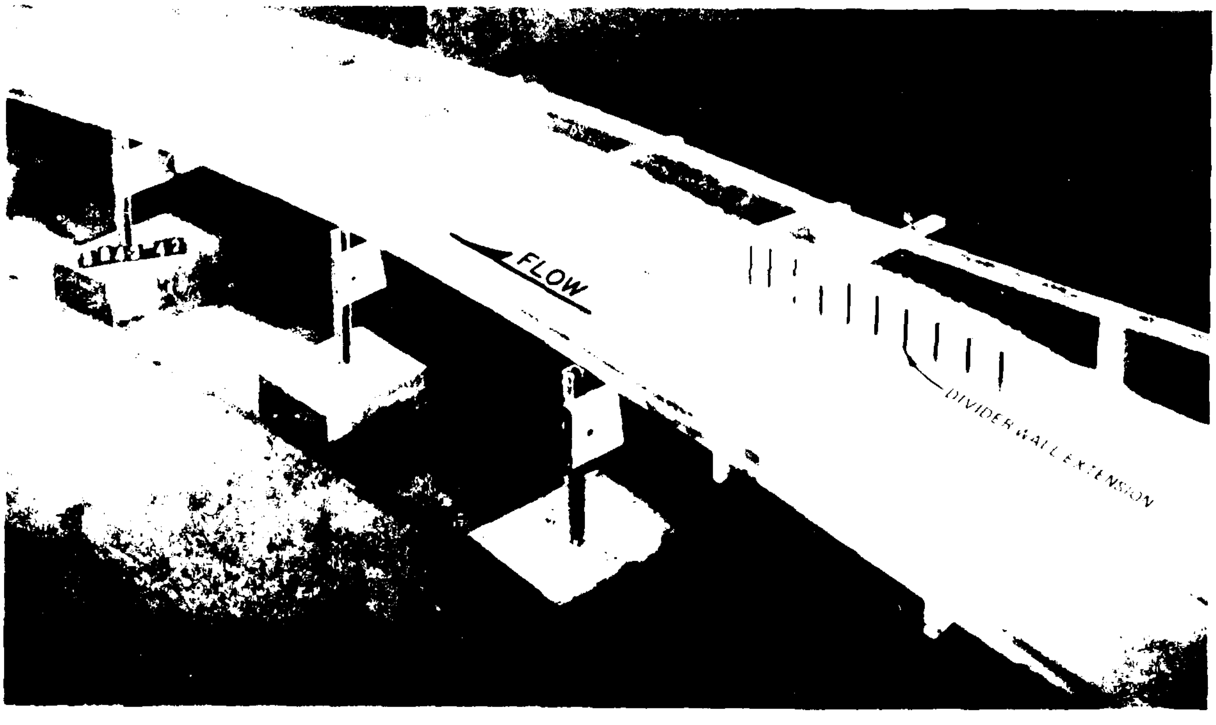


a. Discharge 21,500 cfs



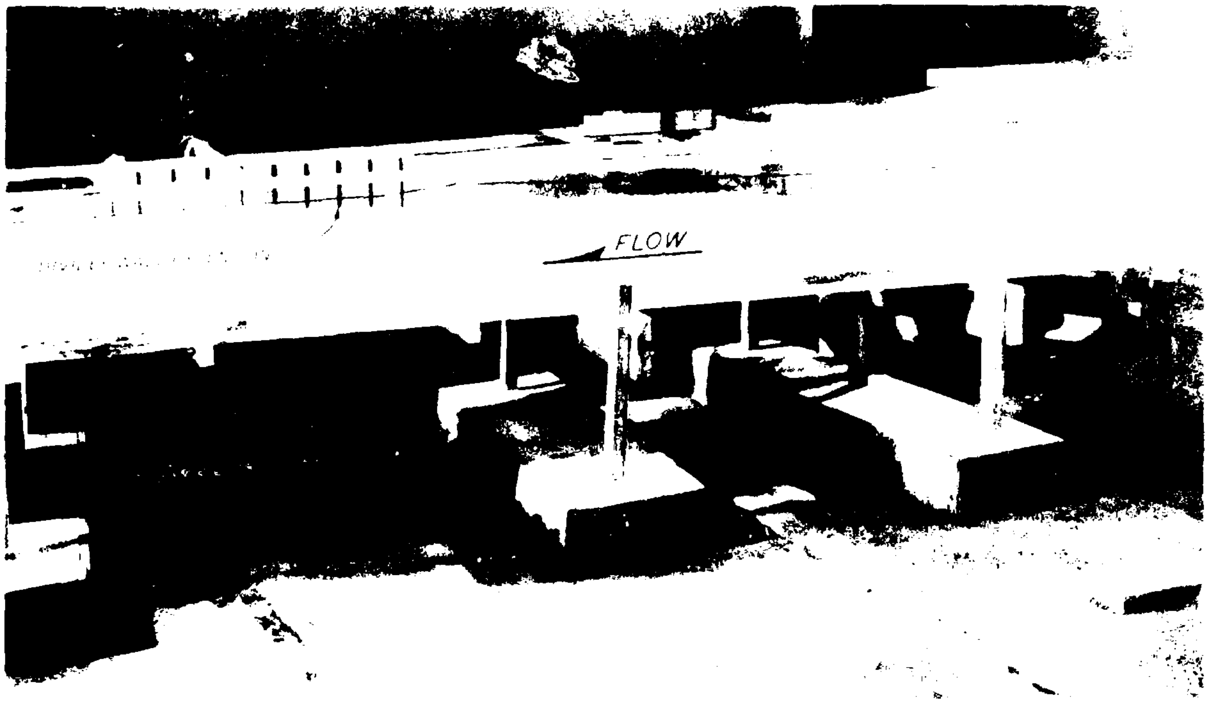


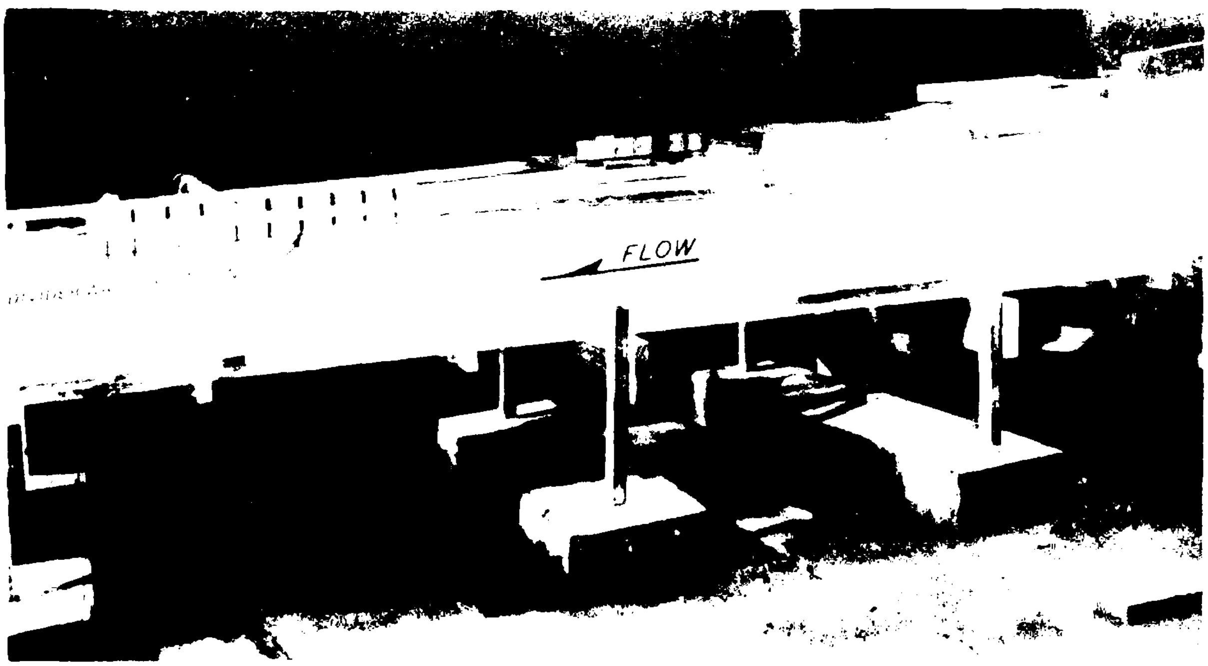
a. Discharge 21,500 cfs

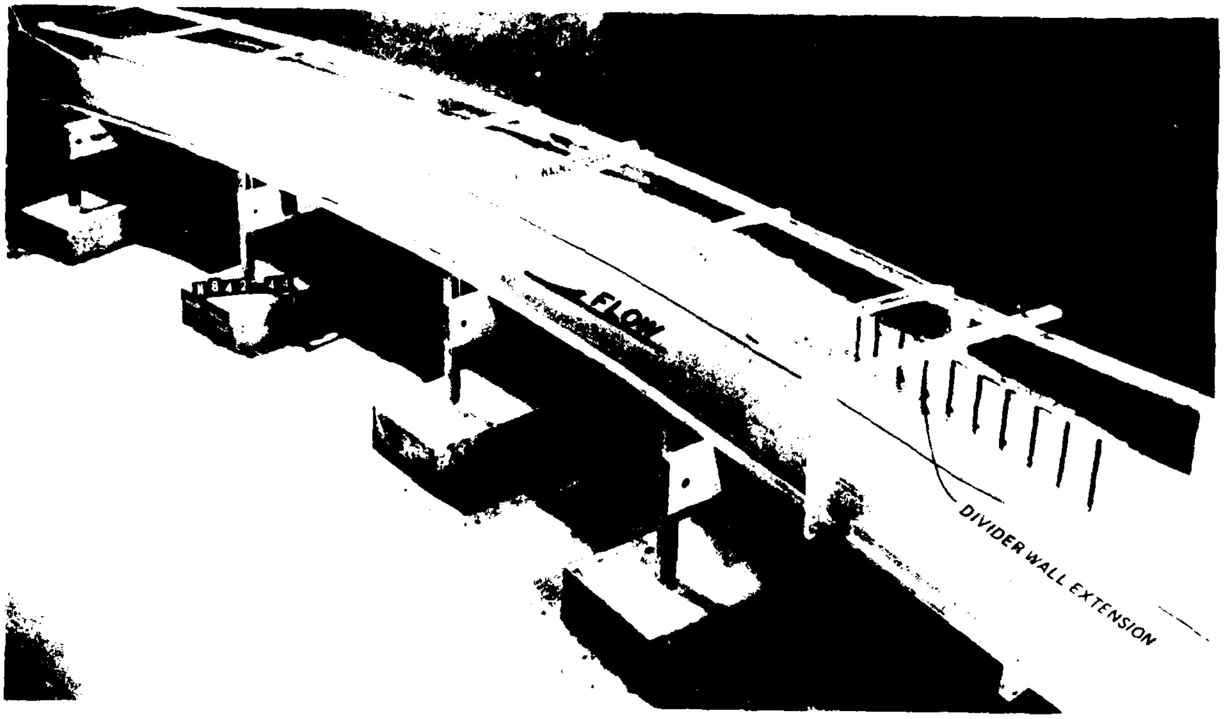


[illegible]

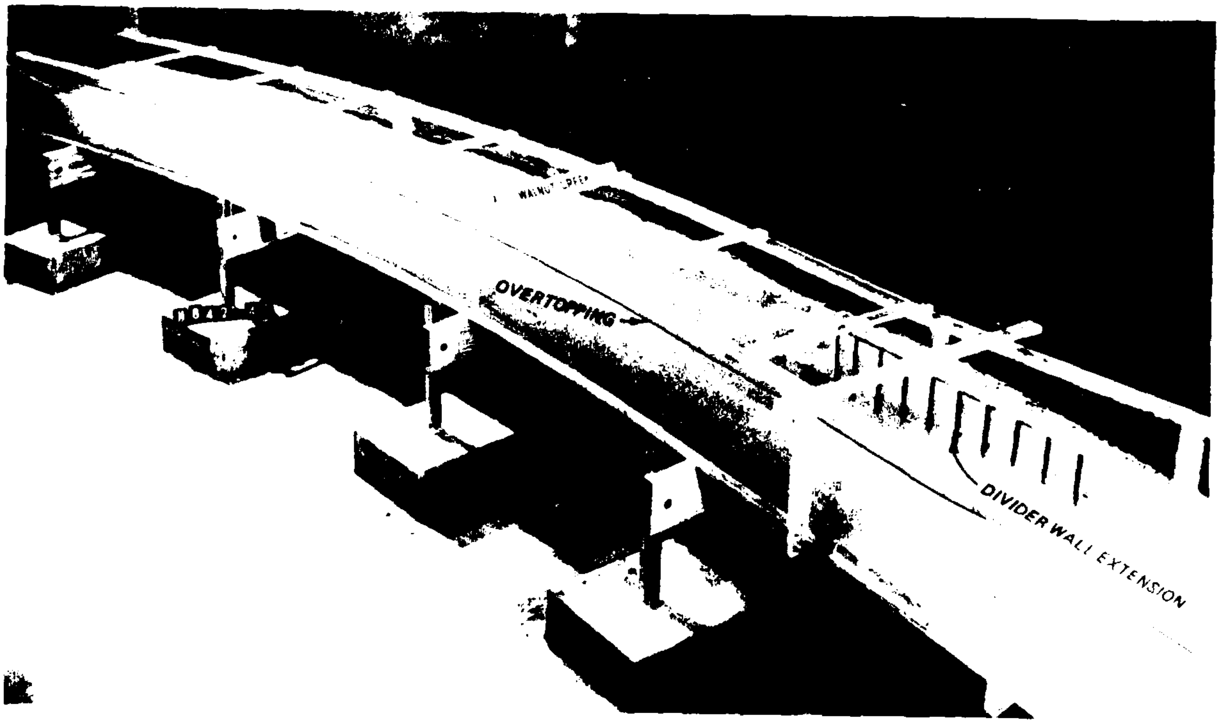
[illegible]


FLOW


FLOW

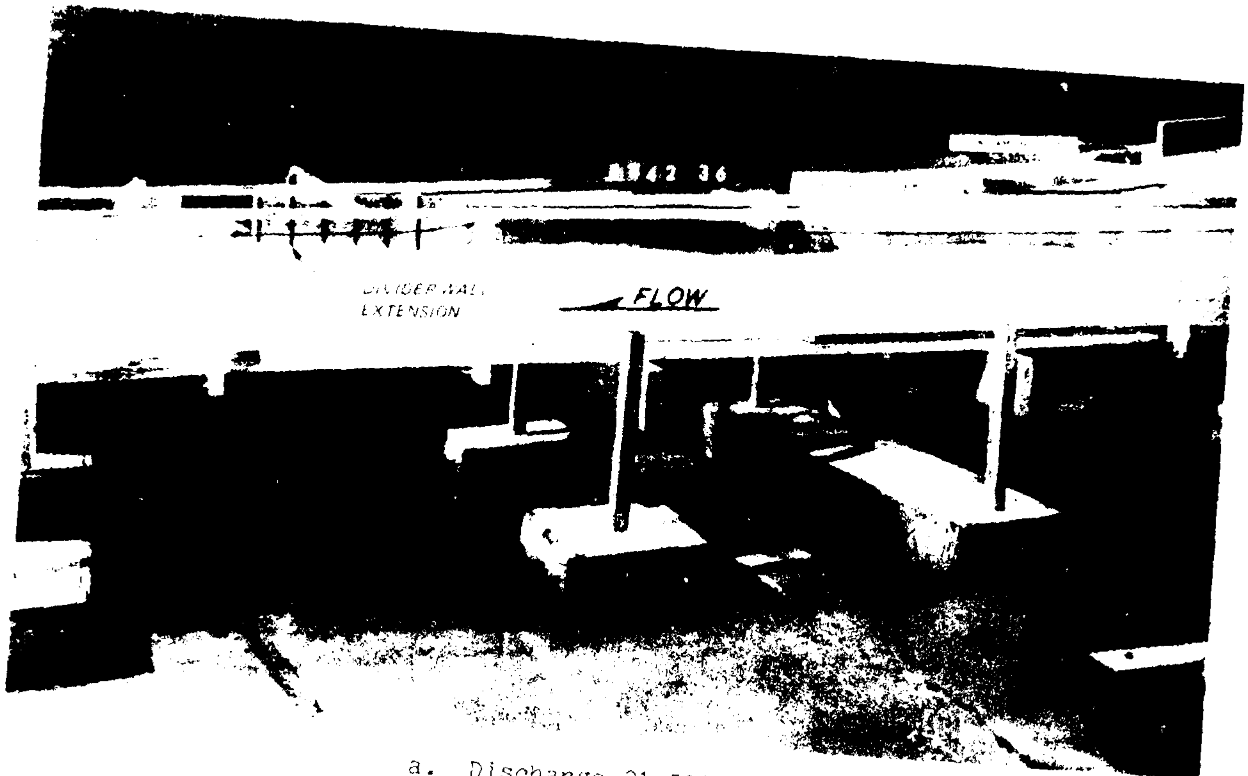


a. Discharge 21,500 cfs

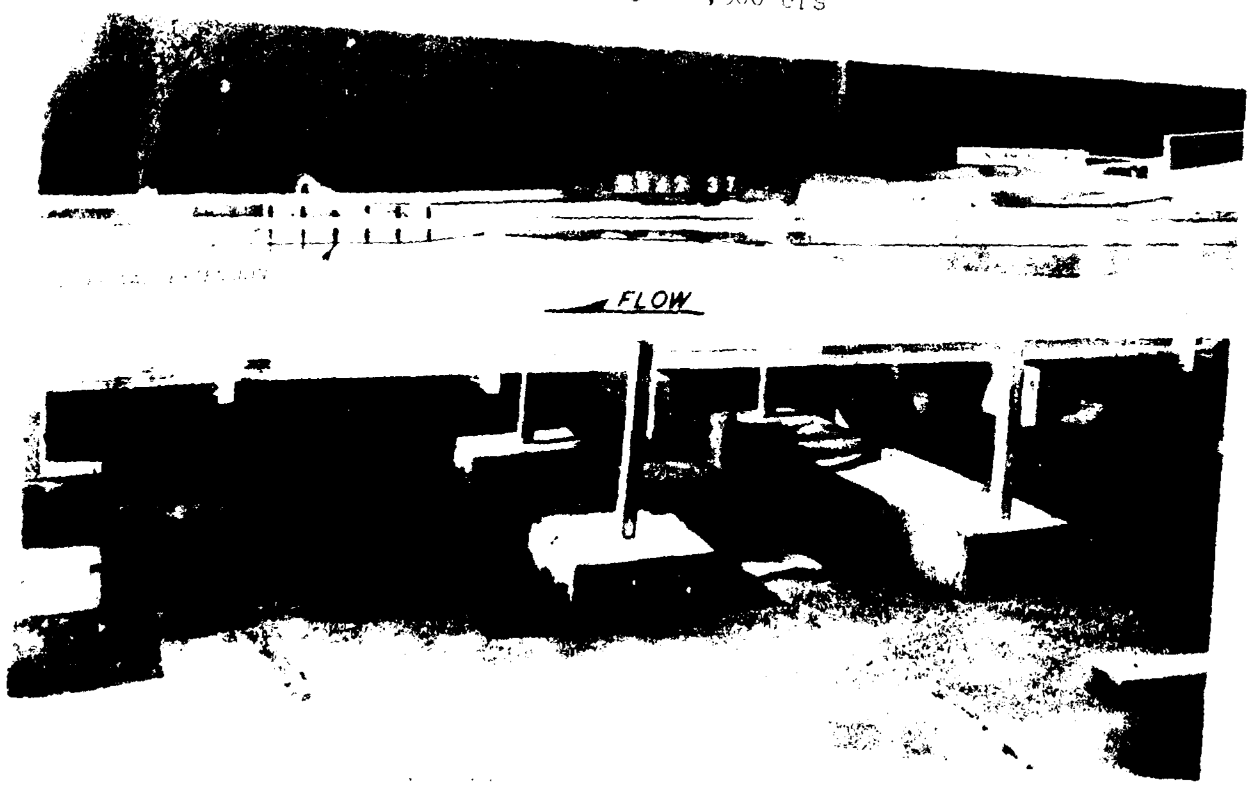


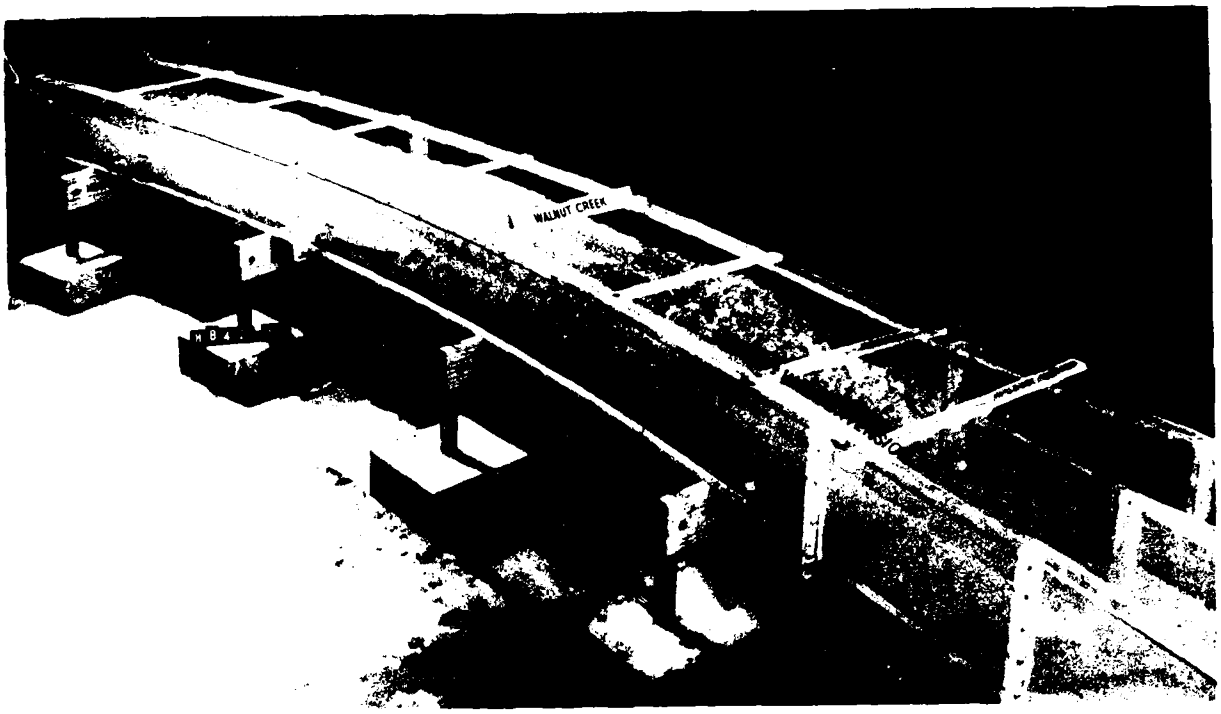
b. Discharge 2?,000 cfs

Photo 16. Walnut Creek, looking downstream in the left [illegible] between sta 582+50 and 578+00 with the 63.8-ft divider ext[illegible] and its nose at 2?.25 ft from the left wall, [illegible]

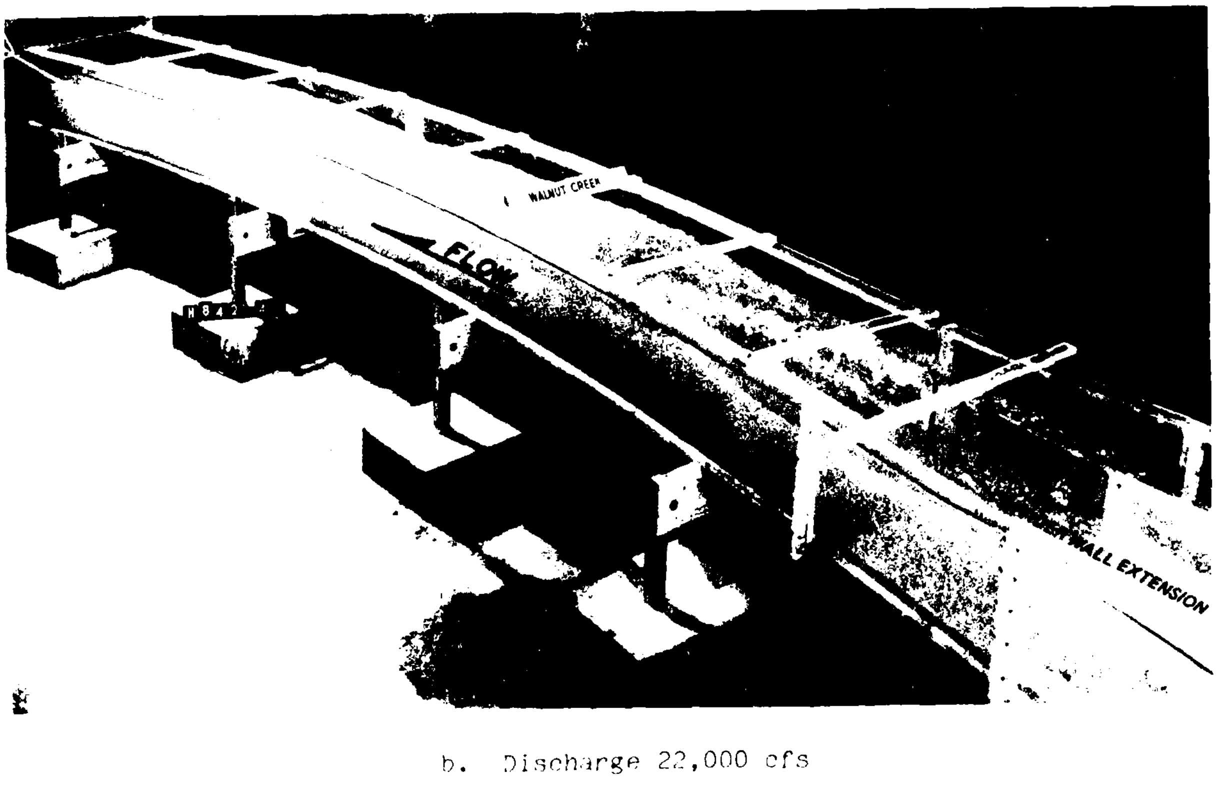


a. Discharge 21,500 cfs



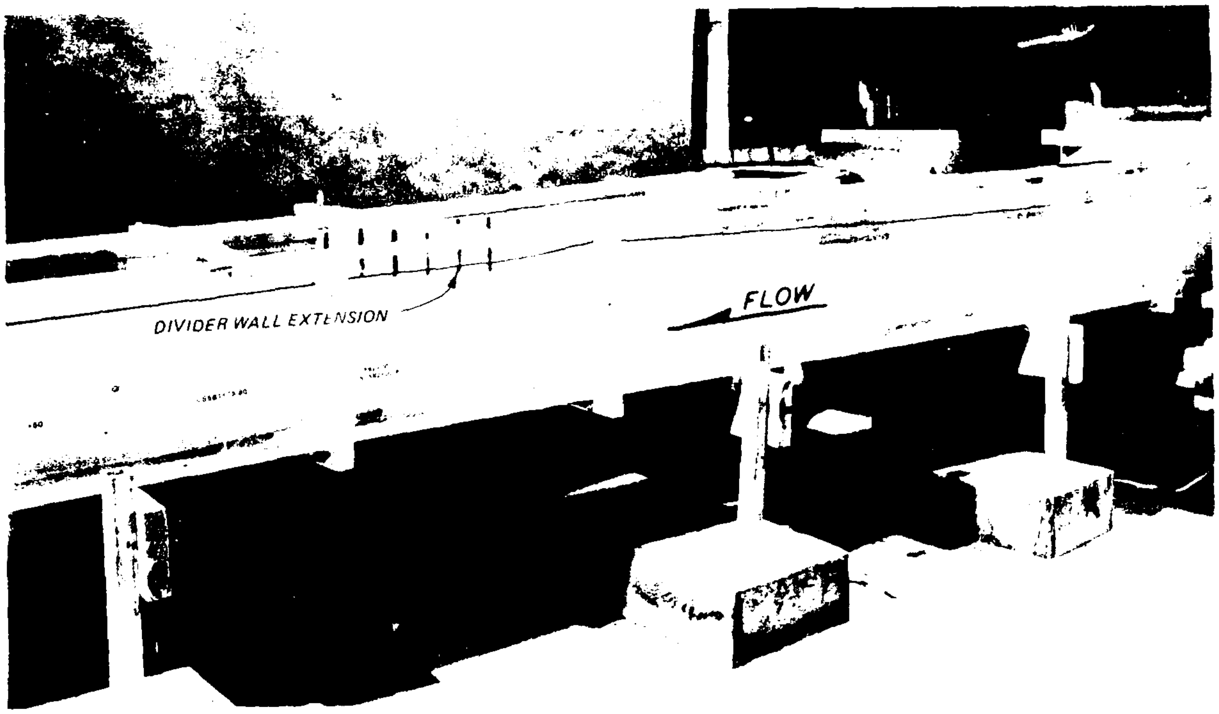


a. Discharge 21,500 cfs

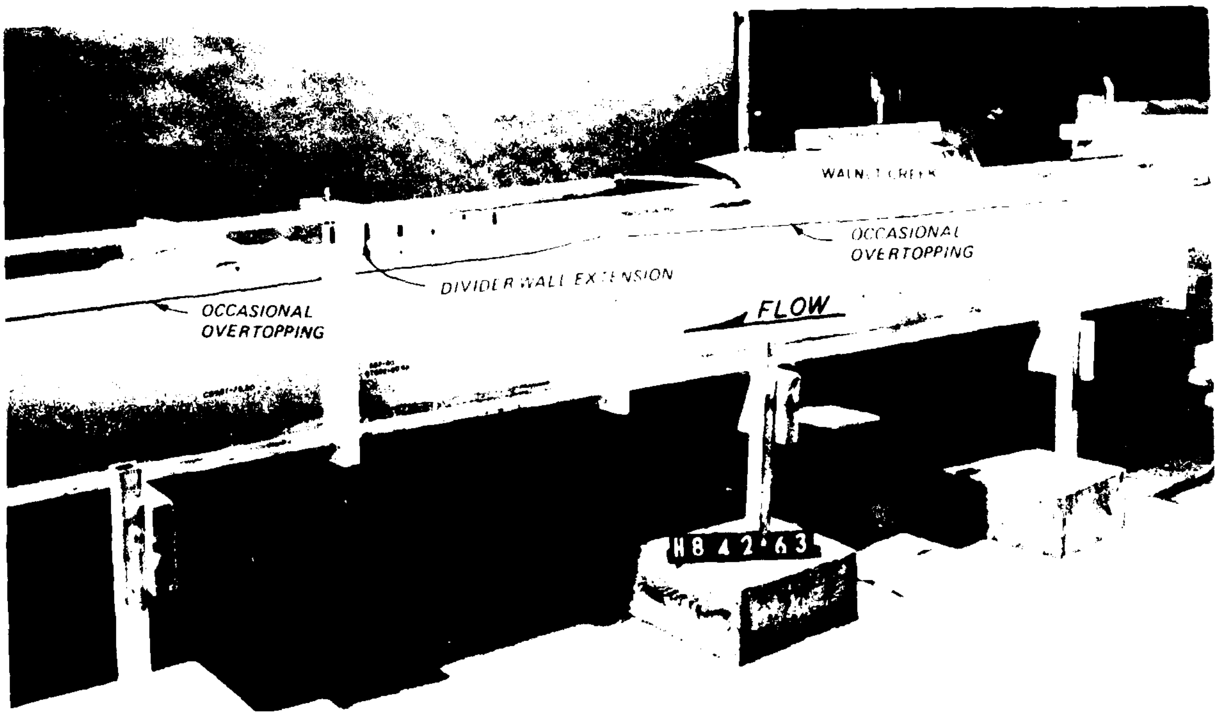


b. Discharge 22,000 cfs

Photo 13. Walnut Creek, looking downstream in the left side of the channel between sta 582+50 and 578+00 with the 40-ft divider extension installed, $n = 0.012$

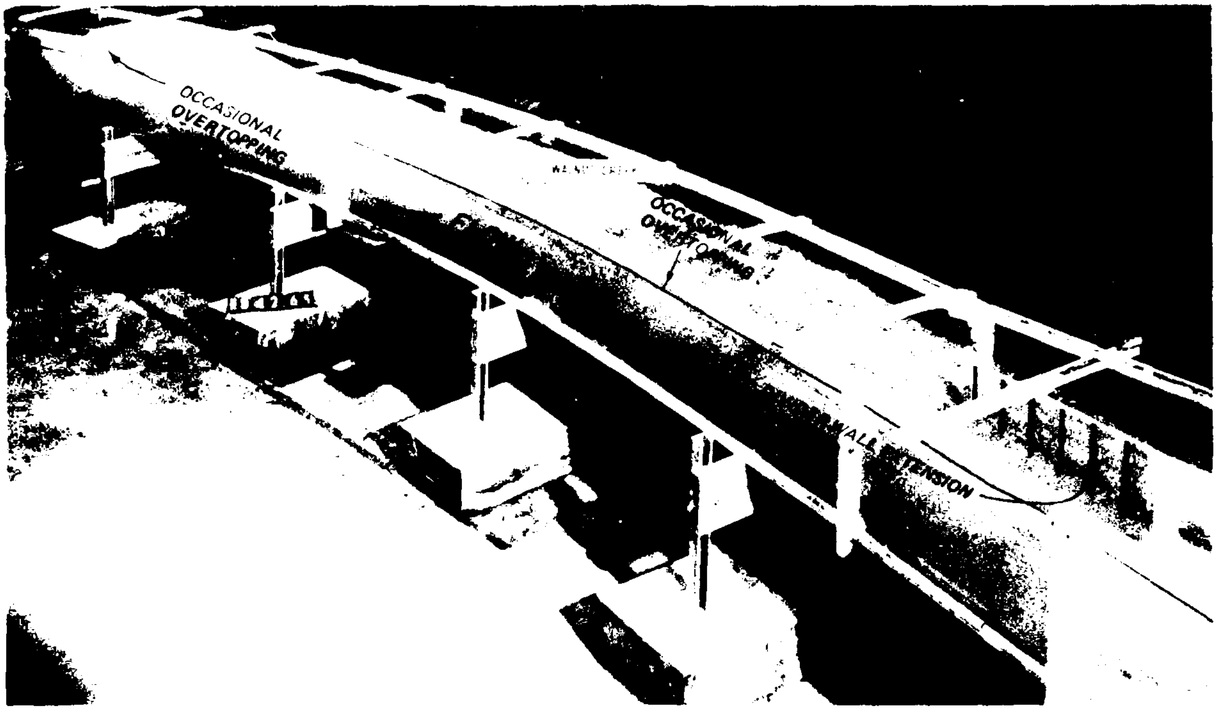


a. Discharge 21,500 cfs

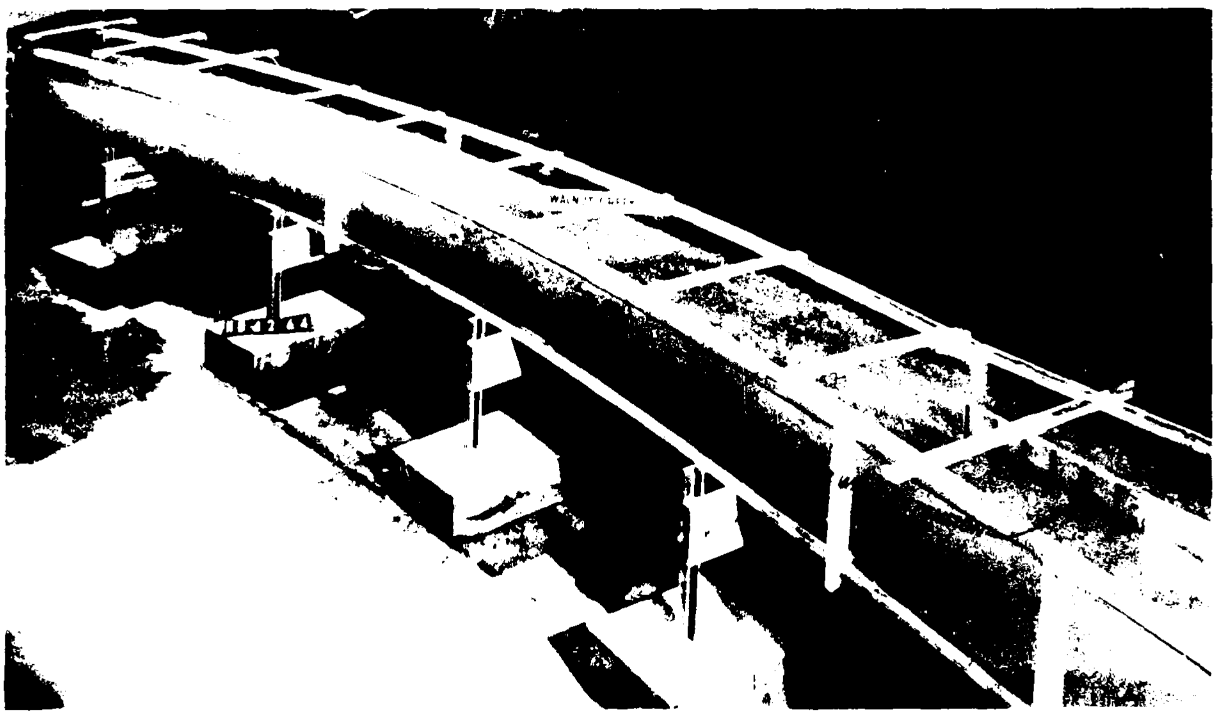


b. Discharge 2[illegible],000 cfs

Photo 17. Walnut Creek-San Ramon Bypass Channel junction, [illegible] in the left side of the channel with the 80-ft divider extension installed, n = 0.0[illegible]

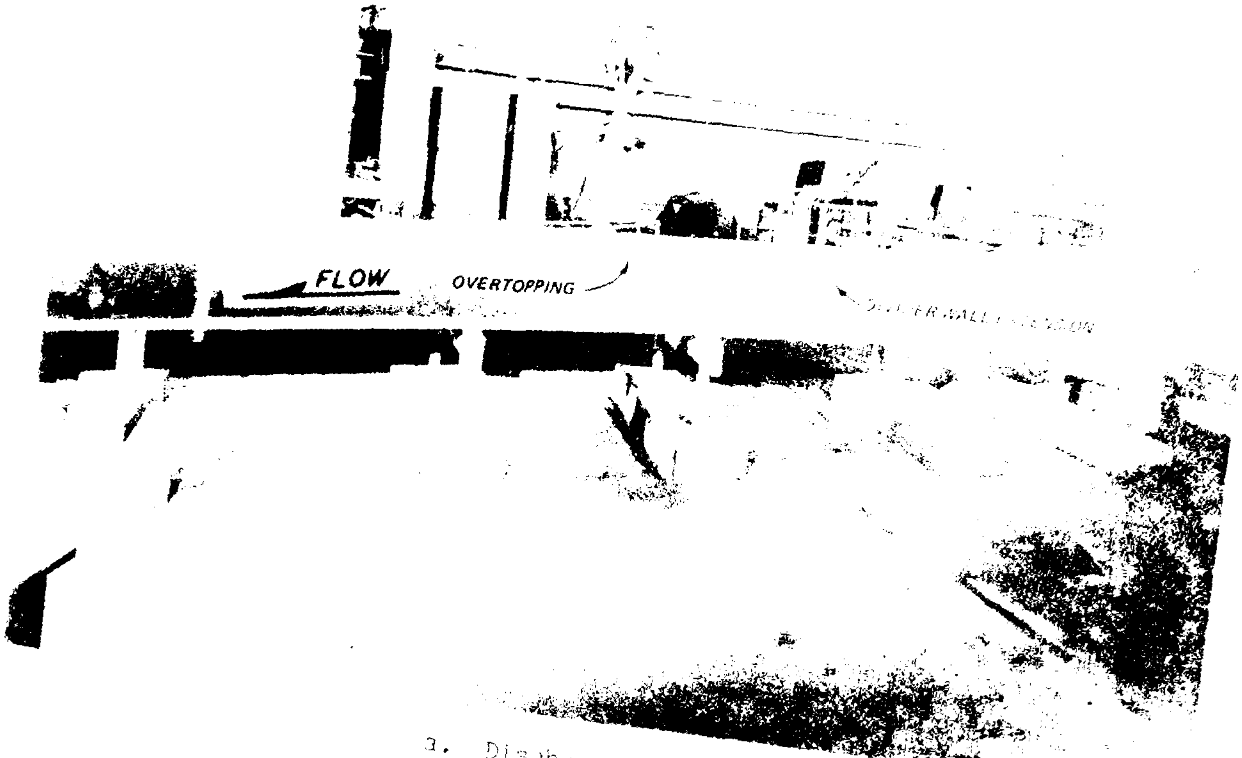


a. Discharge 21,500 cfs

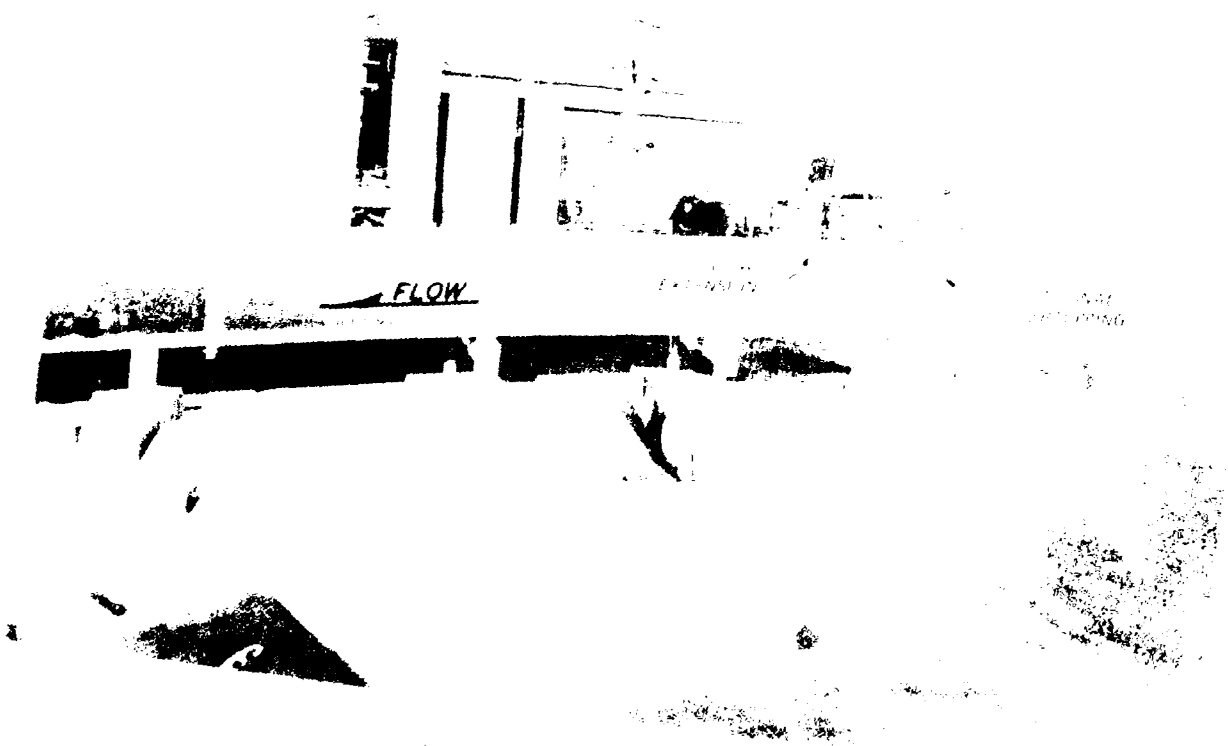


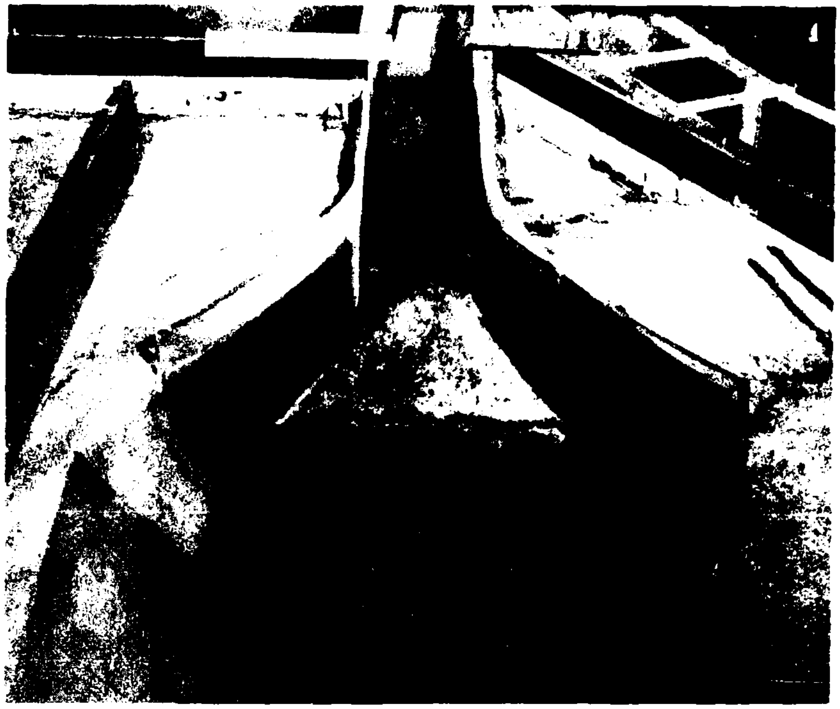
b. Discharge [illegible],[illegible]0[illegible] cfs

Photo [illegible]. Walnut Creek, looking downstream in the left side of the channel between sta [illegible] and [illegible] with the 40-ft divider extension installed, n = [illegible]

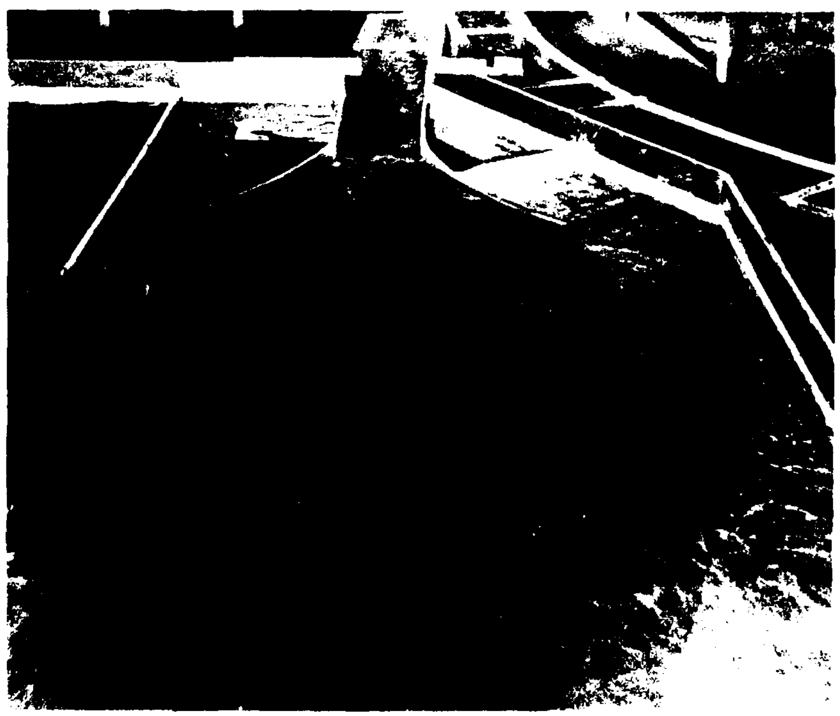


a. Dis[illegible]



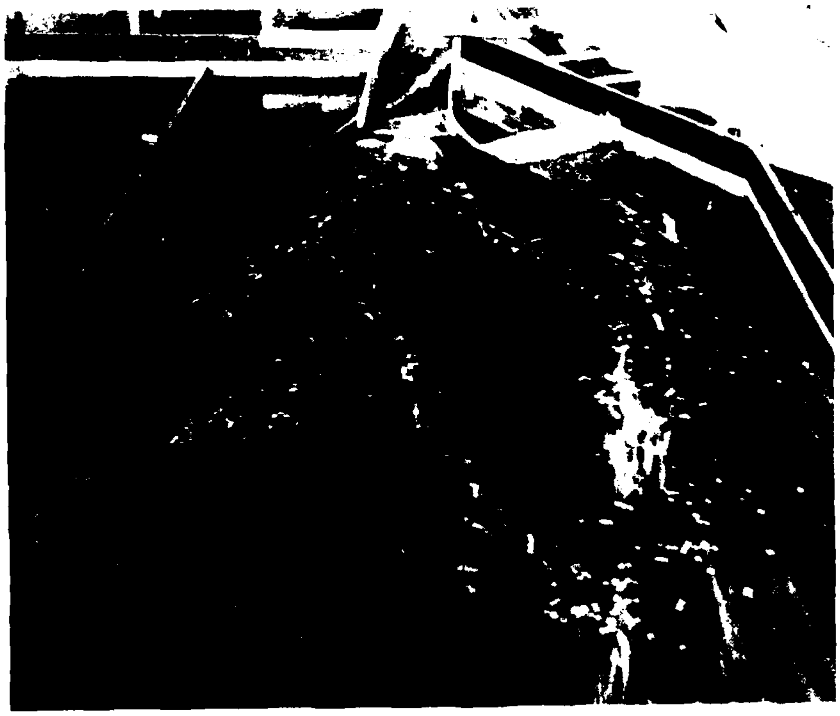


a. Dry bed



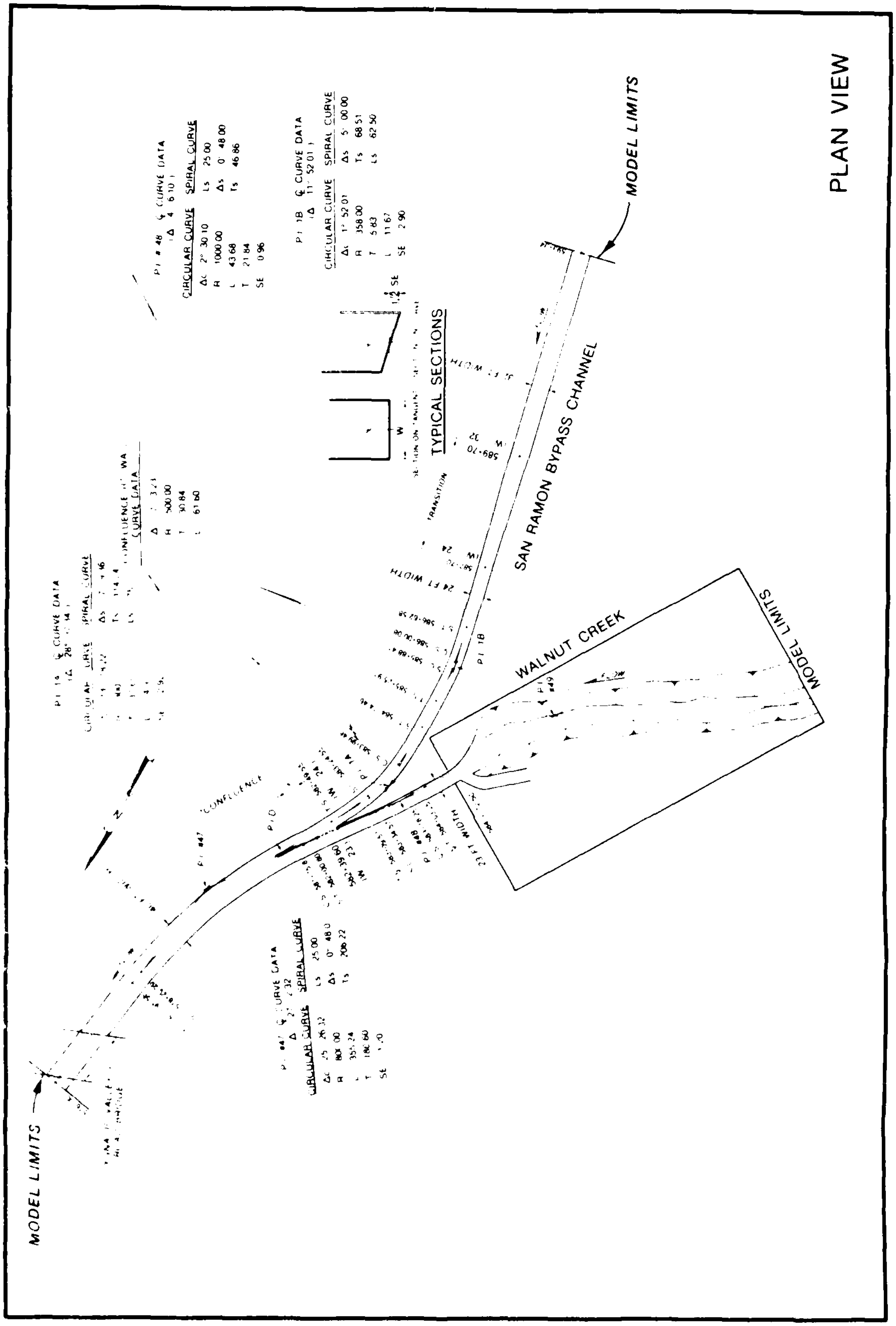
b. Discharge 10,000 cfs

Photo 22. Walnut Creek, looking downstream at the entrance to the high-velocity channel with the symmetrical entrance (Continued)



c. Discharge 10,000 cfs, confetti accents surface flow patterns; exposure time 10 sec (prototype)

Photo 22. (Concluded)


PLAN VIEW
MODEL LIMITS
SAN RAMON BYPASS CHANNEL
WALNUT CREEK
MODEL LIMITS
TYPICAL SECTIONS
TRANSITION
CONFLUENCE
24 FT WIDTH
MODEL LIMITS
CIRCULAR CURVE
SPIRAL CURVE
PI 1B

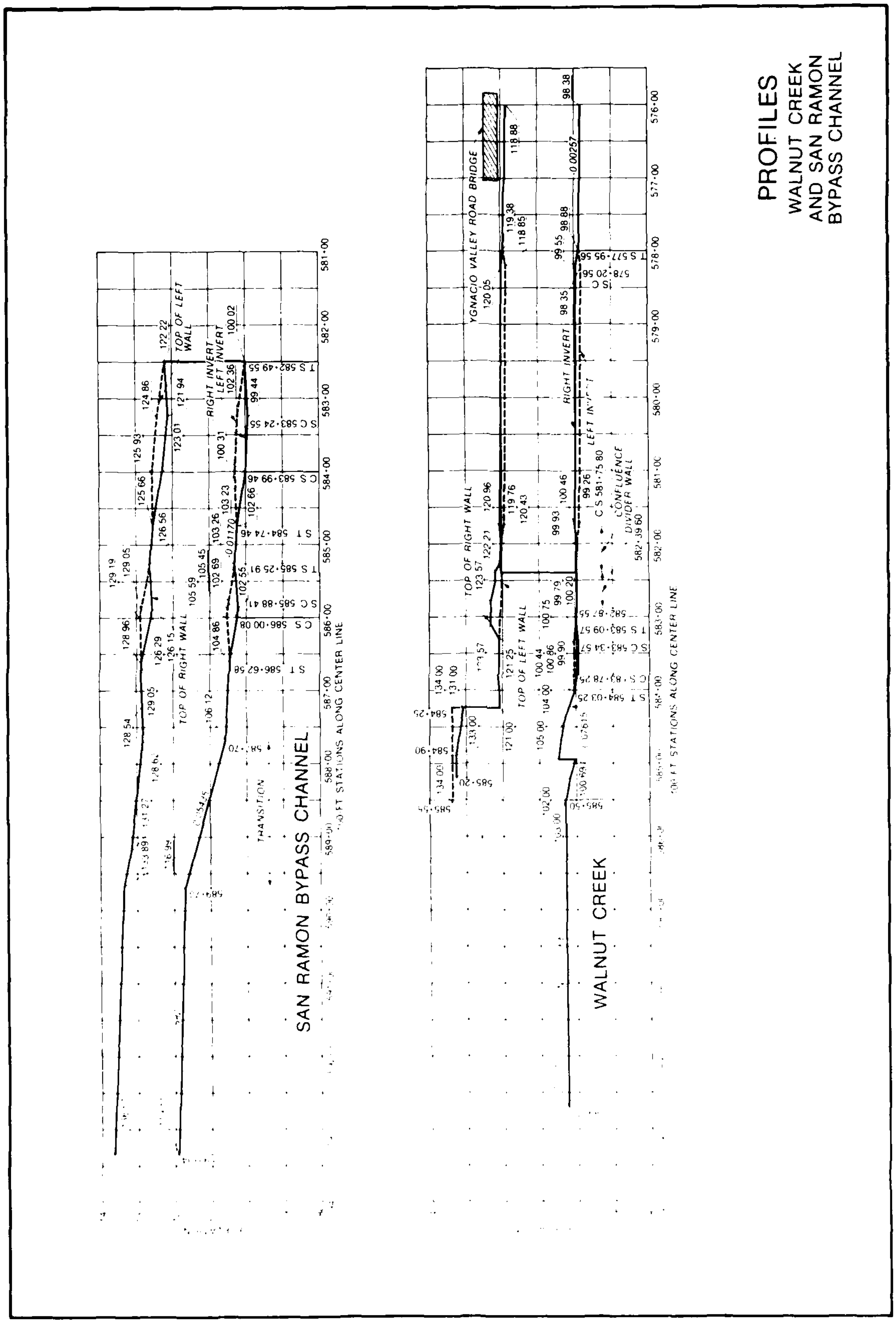
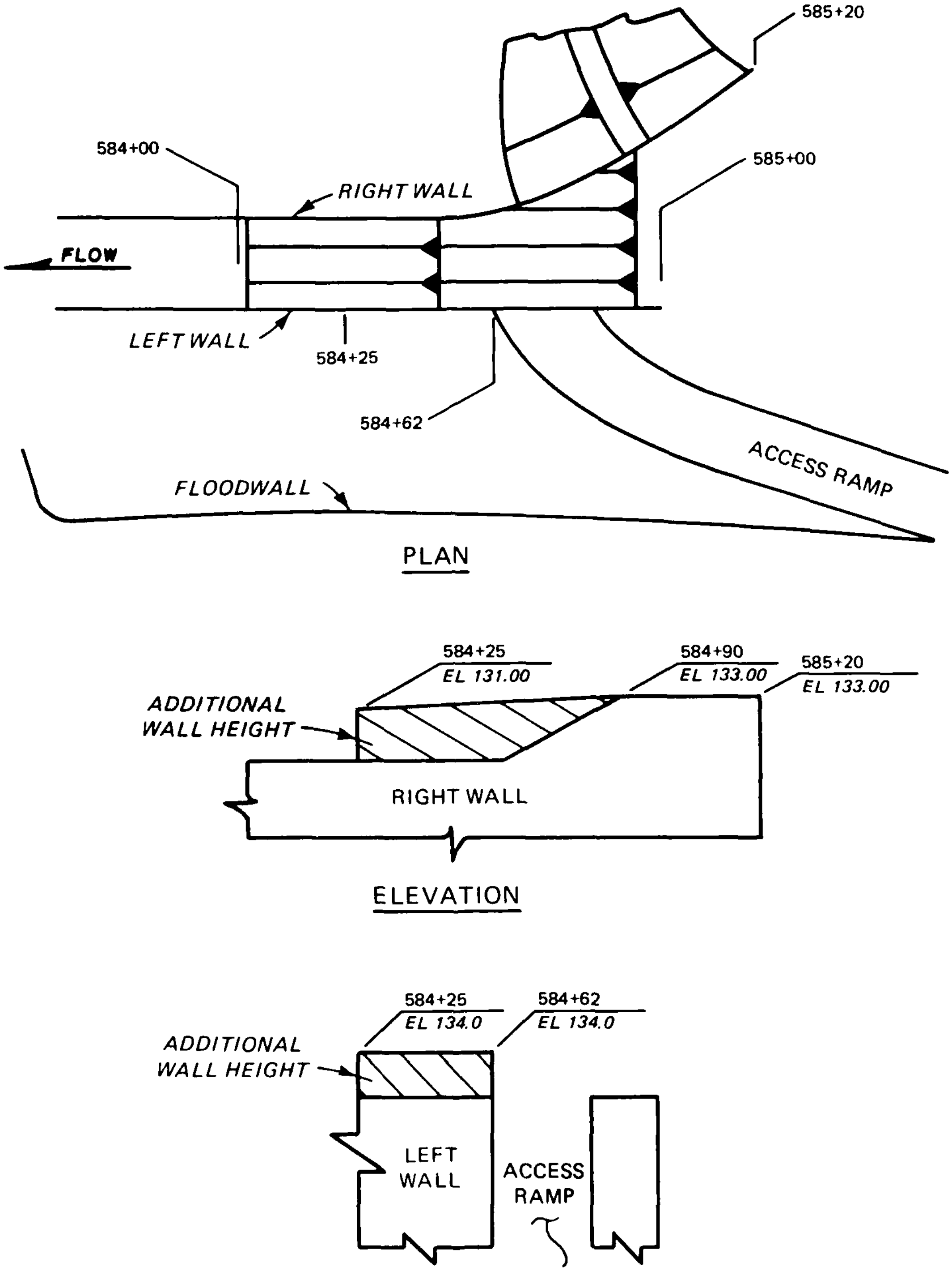
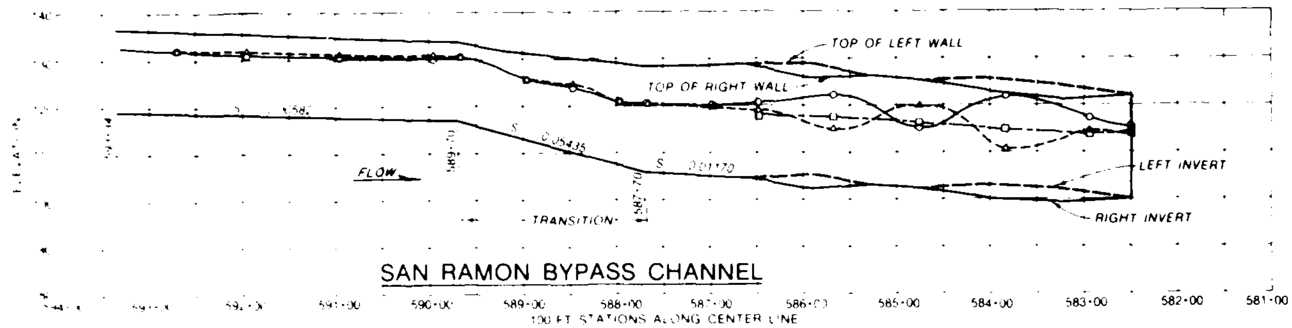

PROFILES
WALNUT CREEK
AND SAN RAMON
BYPASS CHANNEL
SAN RAMON BYPASS CHANNEL
WALNUT CREEK
YGNACIO VALLEY ROAD BRIDGE
TOP OF LEFT WALL
TOP OF RIGHT WALL
RIGHT INVERT
LEFT INVERT
CONFLUENCE
DIVIDER WALL
TRANSITION

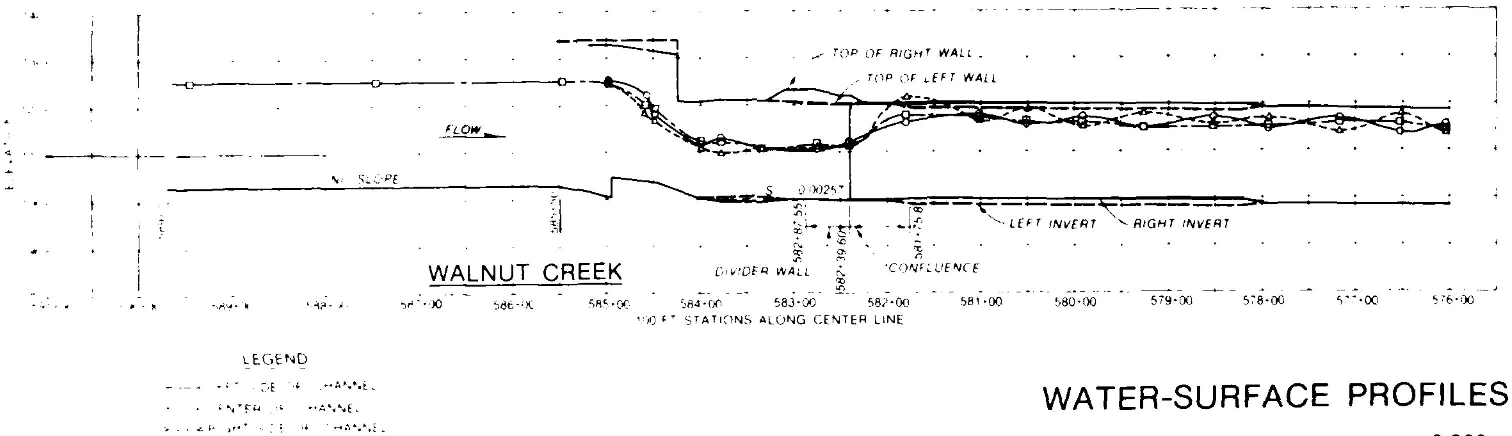
PLATE 2



DETAILS OF RAISED WALL HEIGHT ORIGINAL DESIGN

NOTE: ENTIRE LEFT WALL OF ACCESS RAMP RAISED TO EL 134.0





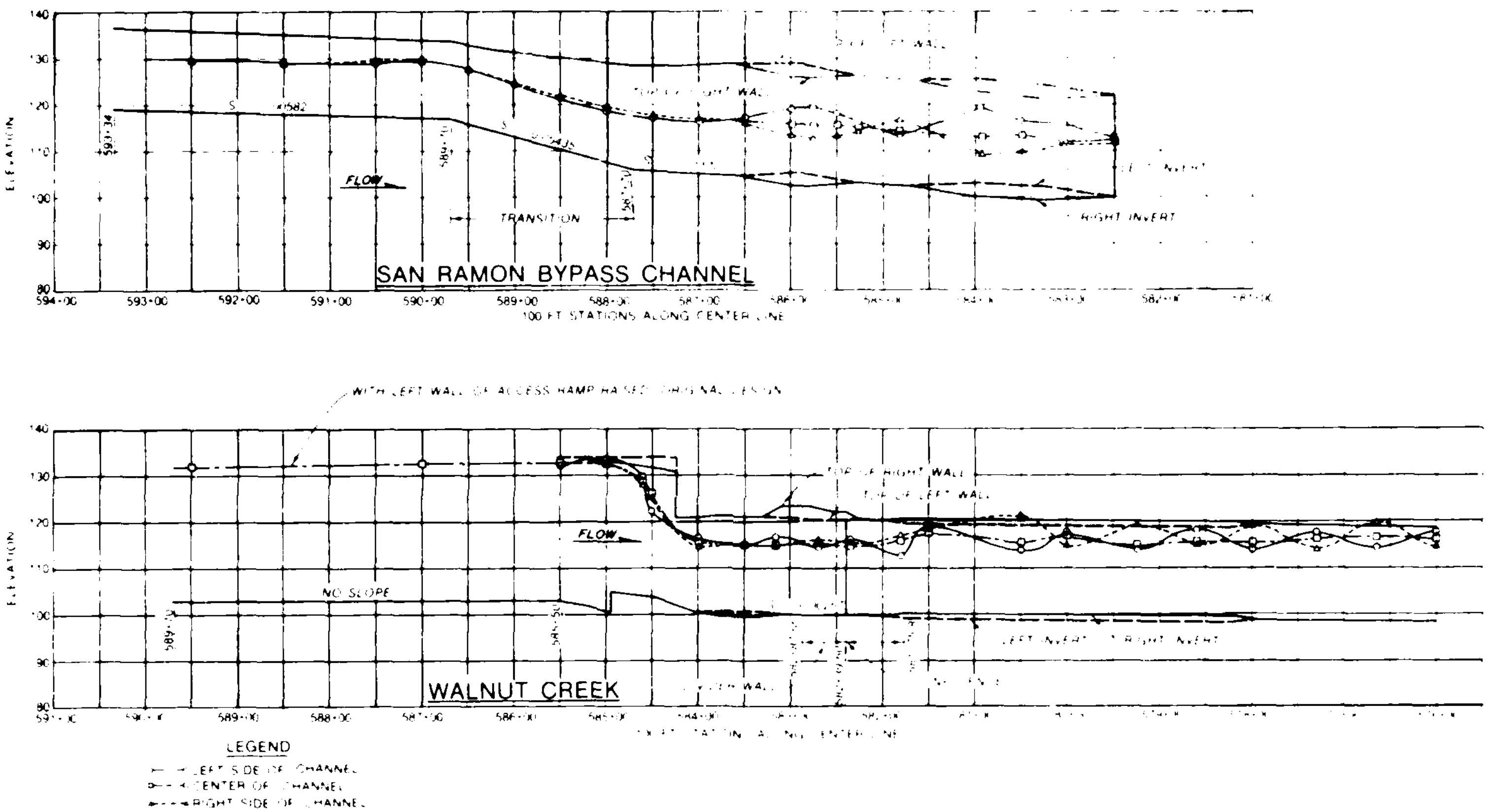
WATER-SURFACE PROFILES

WALNUT CREEK	6,800 cfs
SAN RAMON CREEK (Q[illegible])	15,200 cfs

ORIGINAL DESIGN

n = 0.012

PLATE 4



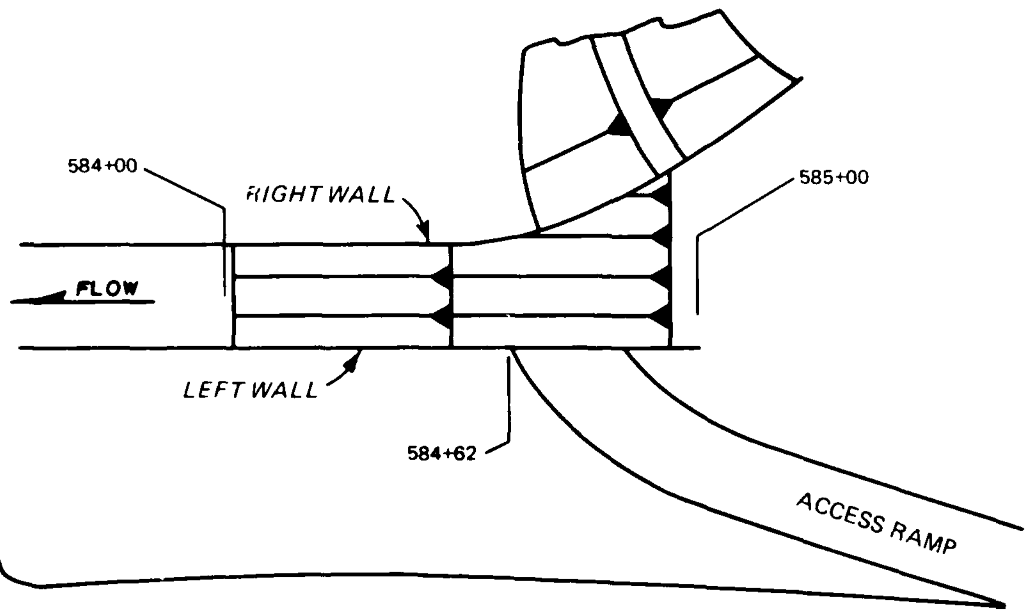
WATER-SURFACE PROFILES

WALNUT CREEK (Q_{100}) 10,000 cfs

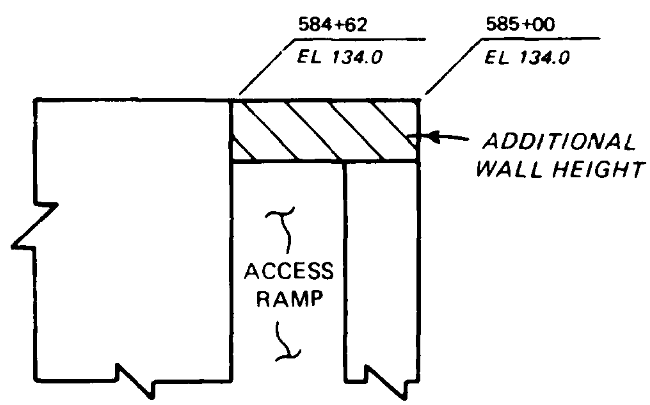
SAN RAMON CREEK 11,500 cfs

ORIGINAL DESIGN

n 0.012

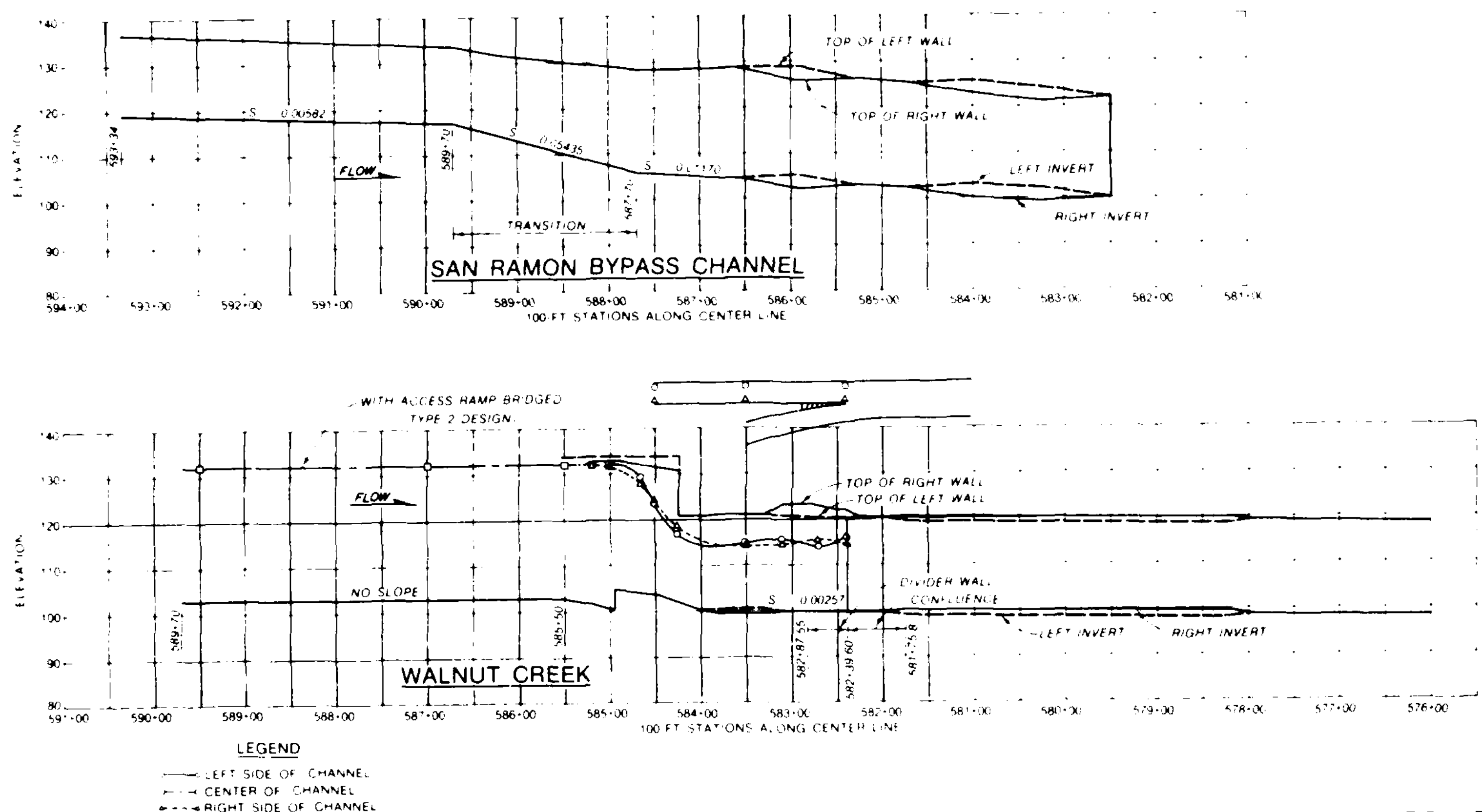


PLAN



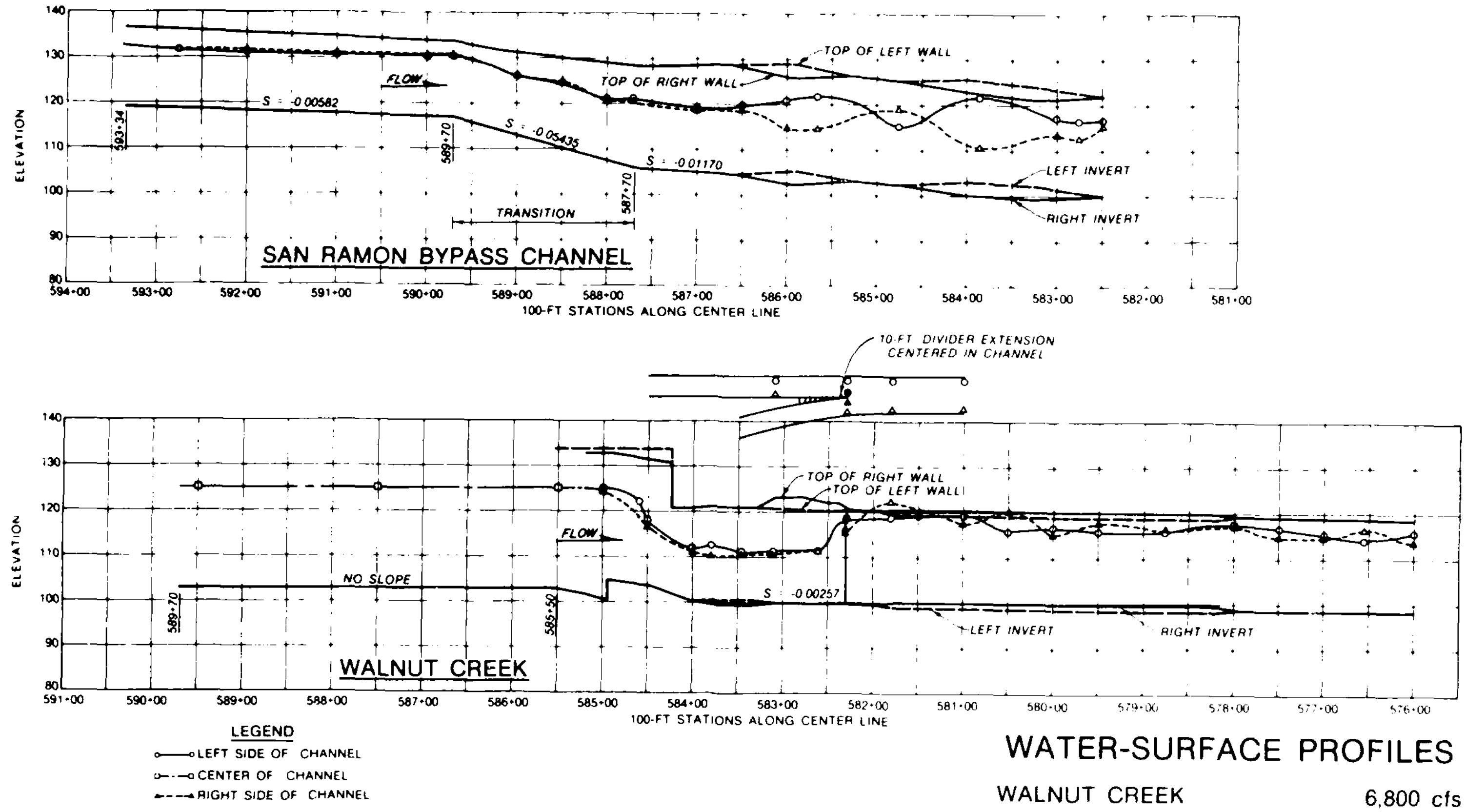
ELEVATION
LEFT WALL

DETAILS OF RAISED WALL HEIGHT
ACCESS RAMP BRIDGED



WATER-SURFACE PROFILES

WALNUT CREEK (Q_{100})	10,000 cfs
SAN RAMON CREEK	11,500 cfs
ACCESS RAMP BRIDGED	
n = 0.012	



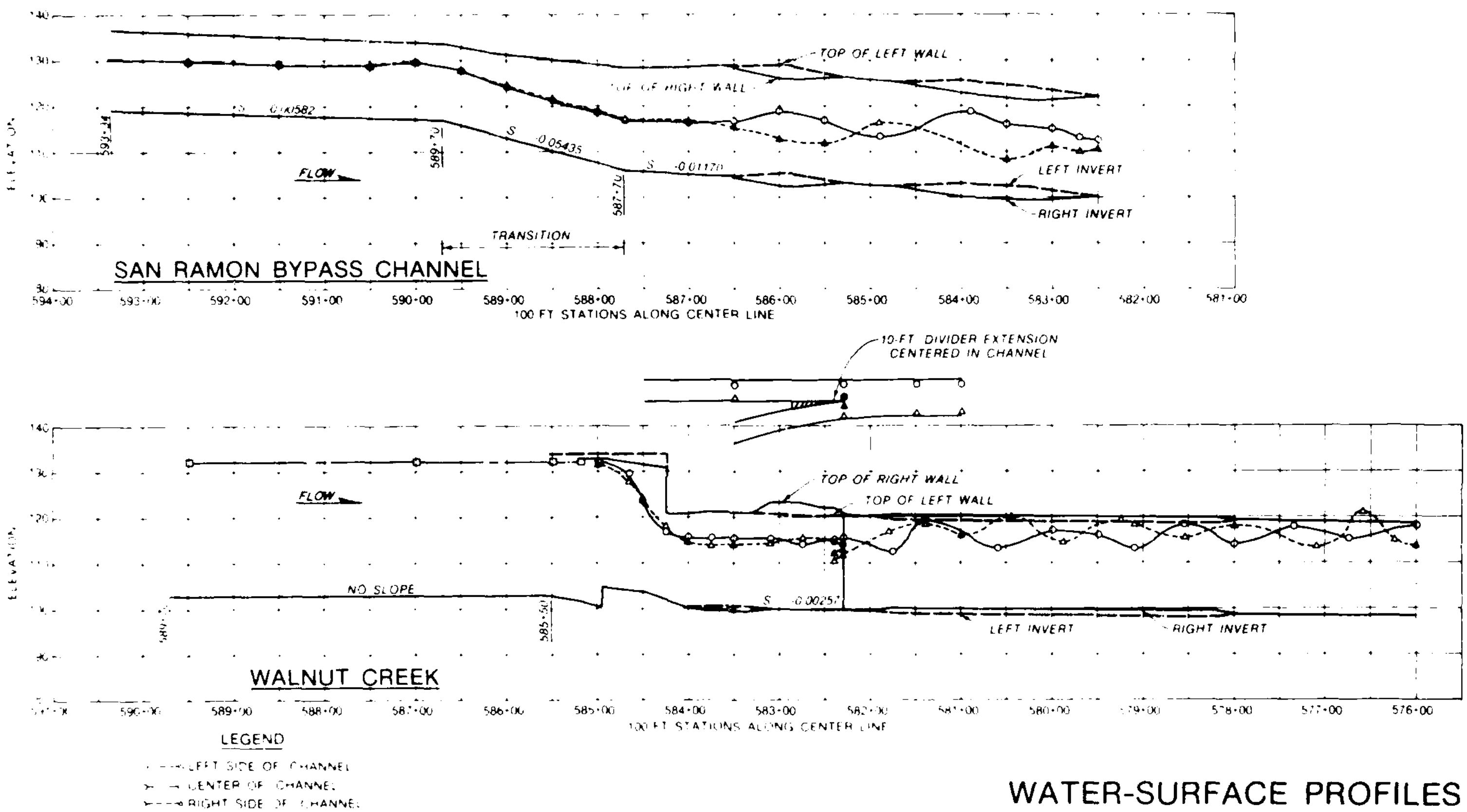
WATER-SURFACE PROFILES

WALNUT CREEK	6,800 cfs
SAN RAMON CREEK (Q_{100})	15,200 cfs

10.0-FT DIVIDER EXTENSION

ACCESS RAMP BRIDGED

$n = 0.012$



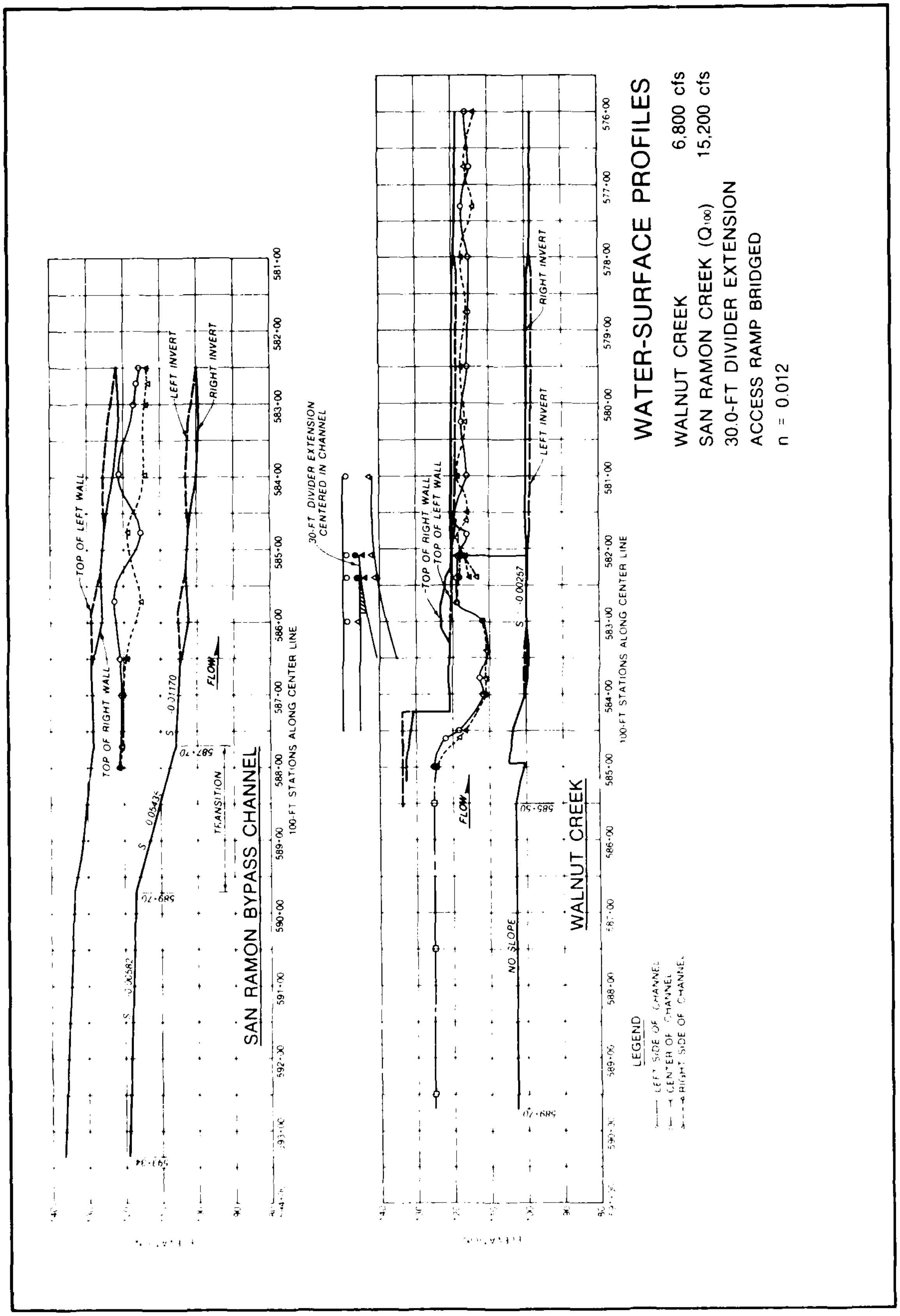
WATER-SURFACE PROFILES

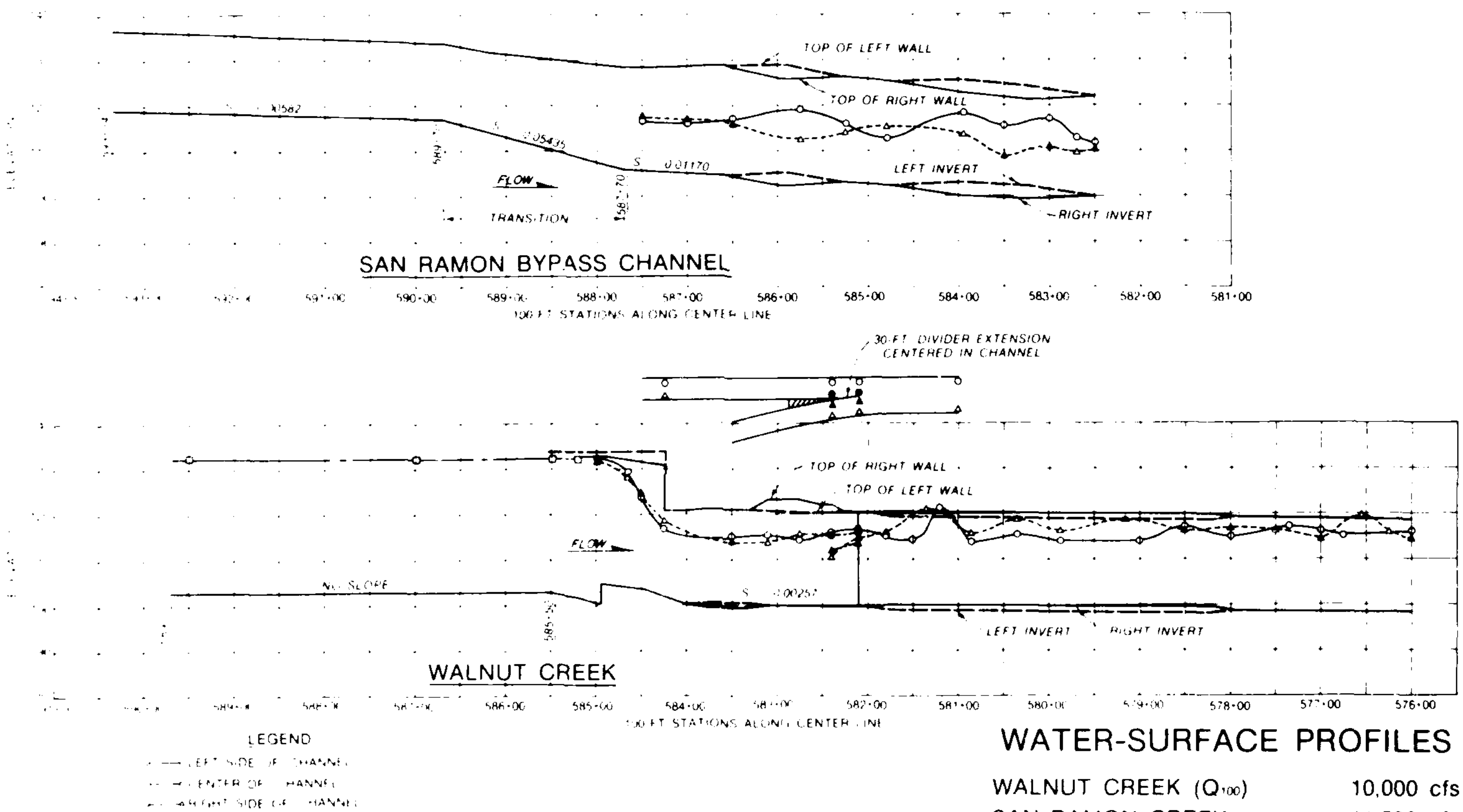
WALNUT CREEK (Q_{100})	10,000 cfs
SAN RAMON CREEK	11,500 cfs

10 0-FT DIVIDER EXTENSION

ACCESS RAMP BRIDGED

n = 0.012


WATER-SURFACE PROFILES
WALNUT CREEK 6,800 cfs
SAN RAMON CREEK (Q100) 15,200 cfs
30.0-FT DIVIDER EXTENSION
ACCESS RAMP BRIDGED
n = 0.012
SAN RAMON BYPASS CHANNEL
WALNUT CREEK
TOP OF LEFT WALL
TOP OF RIGHT WALL
LEFT INVERT
RIGHT INVERT
TRANSITION
FLOW
30-FT DIVIDER EXTENSION CENTERED IN CHANNEL
NO SLOPE
100-FT STATIONS ALONG CENTER LINE
LEGEND
LEFT SIDE OF CHANNEL
CENTER OF CHANNEL
RIGHT SIDE OF CHANNEL
ELEVATION



WATER-SURFACE PROFILES

WALNUT CREEK (Q_{100})	10,000 cfs
SAN RAMON CREEK	11,500 cfs

30.0-FT DIVIDER EXTENSION

ACCESS RAMP BRIDGED

$n = 0.012$

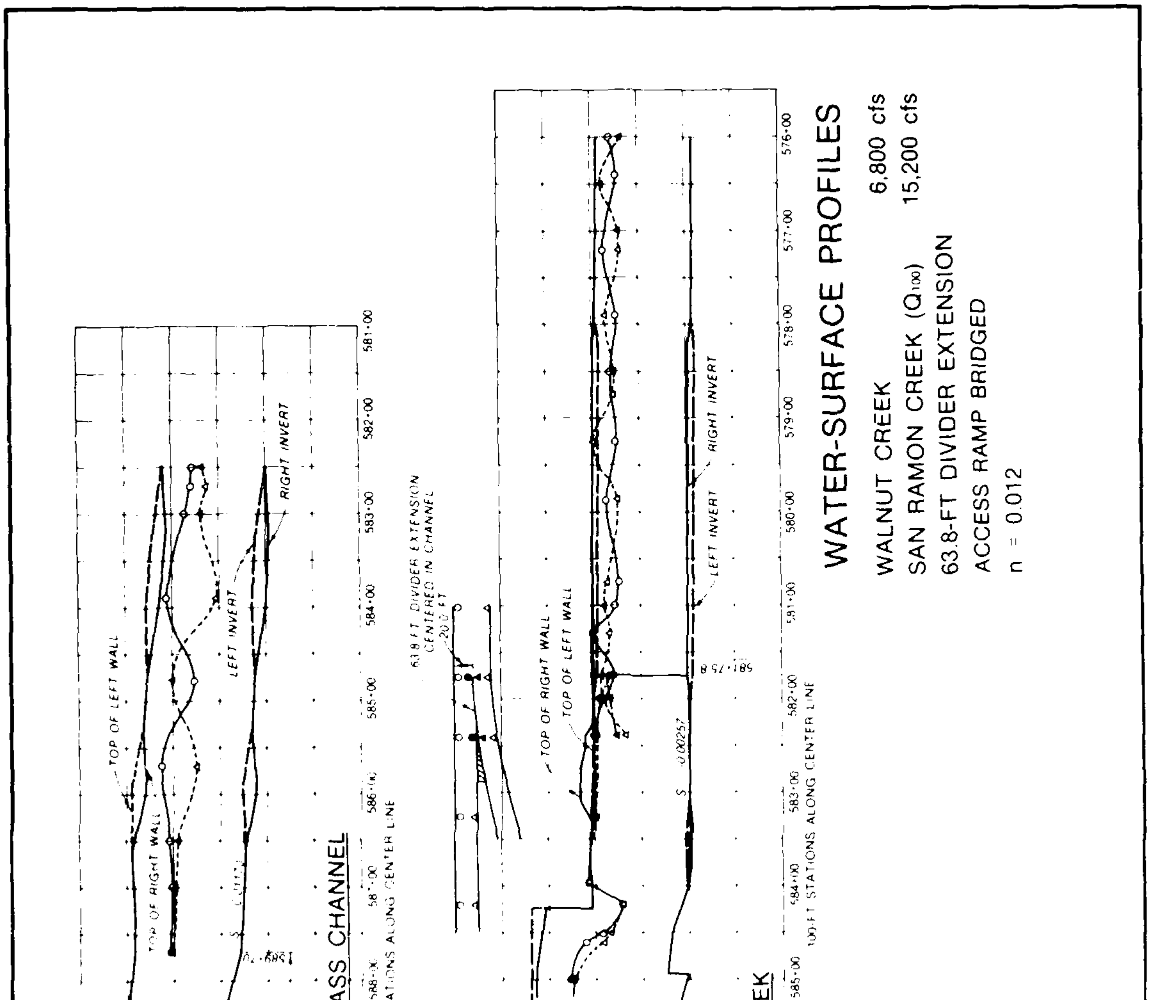
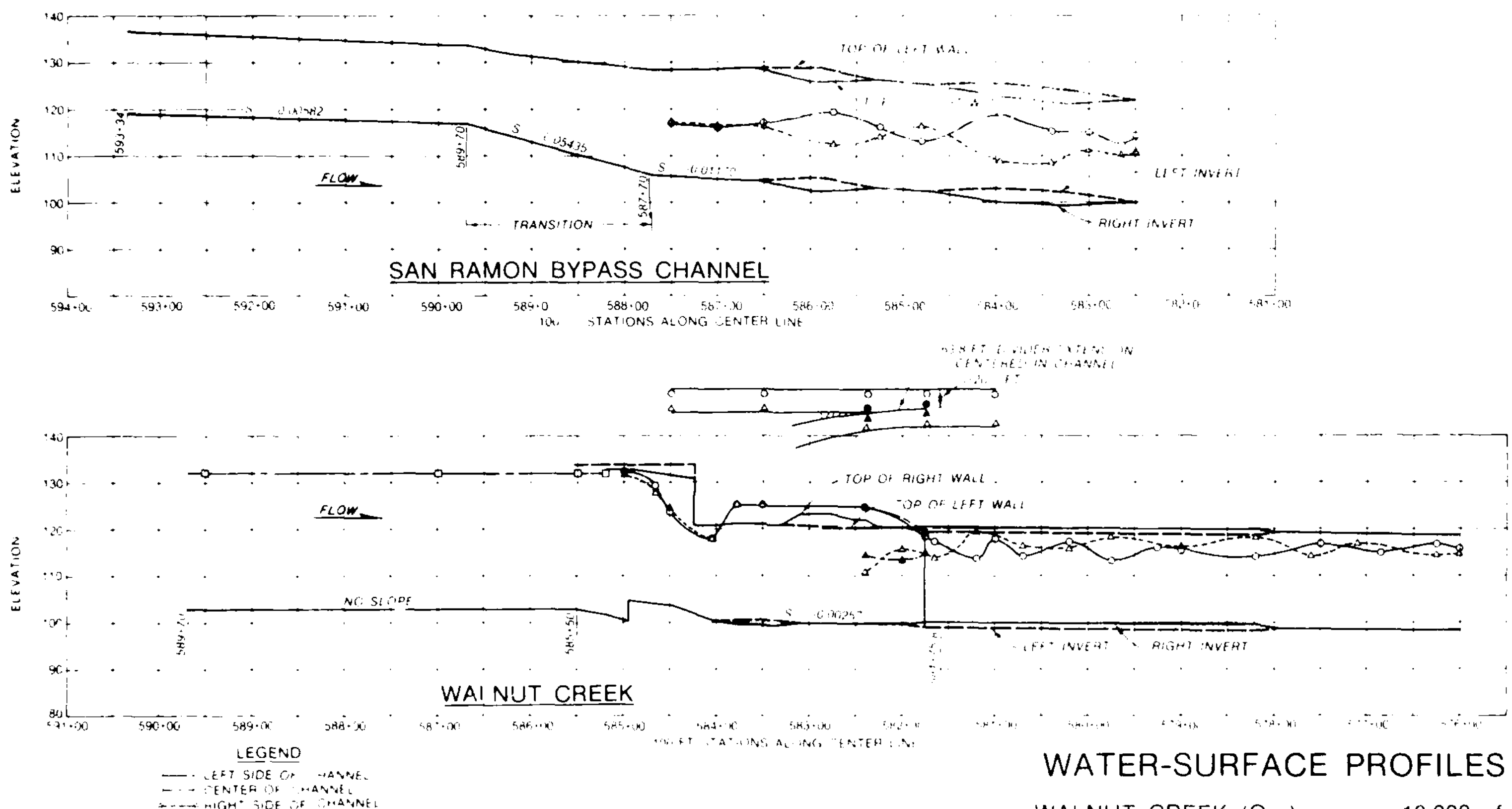

WATER-SURFACE PROFILES
WALNUT CREEK 6,800 cfs
SAN RAMON CREEK (Q100) 15,200 cfs
63.8-FT DIVIDER EXTENSION
ACCESS RAMP BRIDGED
n = 0.012
SAN RAMON BYPASS CHANNEL
TOP OF LEFT WALL
TOP OF RIGHT WALL
LEFT INVERT
RIGHT INVERT
63.8 FT DIVIDER EXTENSION CENTERED IN CHANNEL
20.0 FT
TOP OF RIGHT WALL
TOP OF LEFT WALL
LEFT INVERT
RIGHT INVERT
581+75.8
100-FT STATIONS ALONG CENTER LINE
FLOW
WALNUT CREEK

PLATE 12



WATER-SURFACE PROFILES

WALNUT CREEK (Q-)	10,000 cfs
SAN RAMON CREEK	11,500 cfs

63.8-FT DIVIDER EXTENSION

ACCESS RAMP BRIDGED

n 0.012

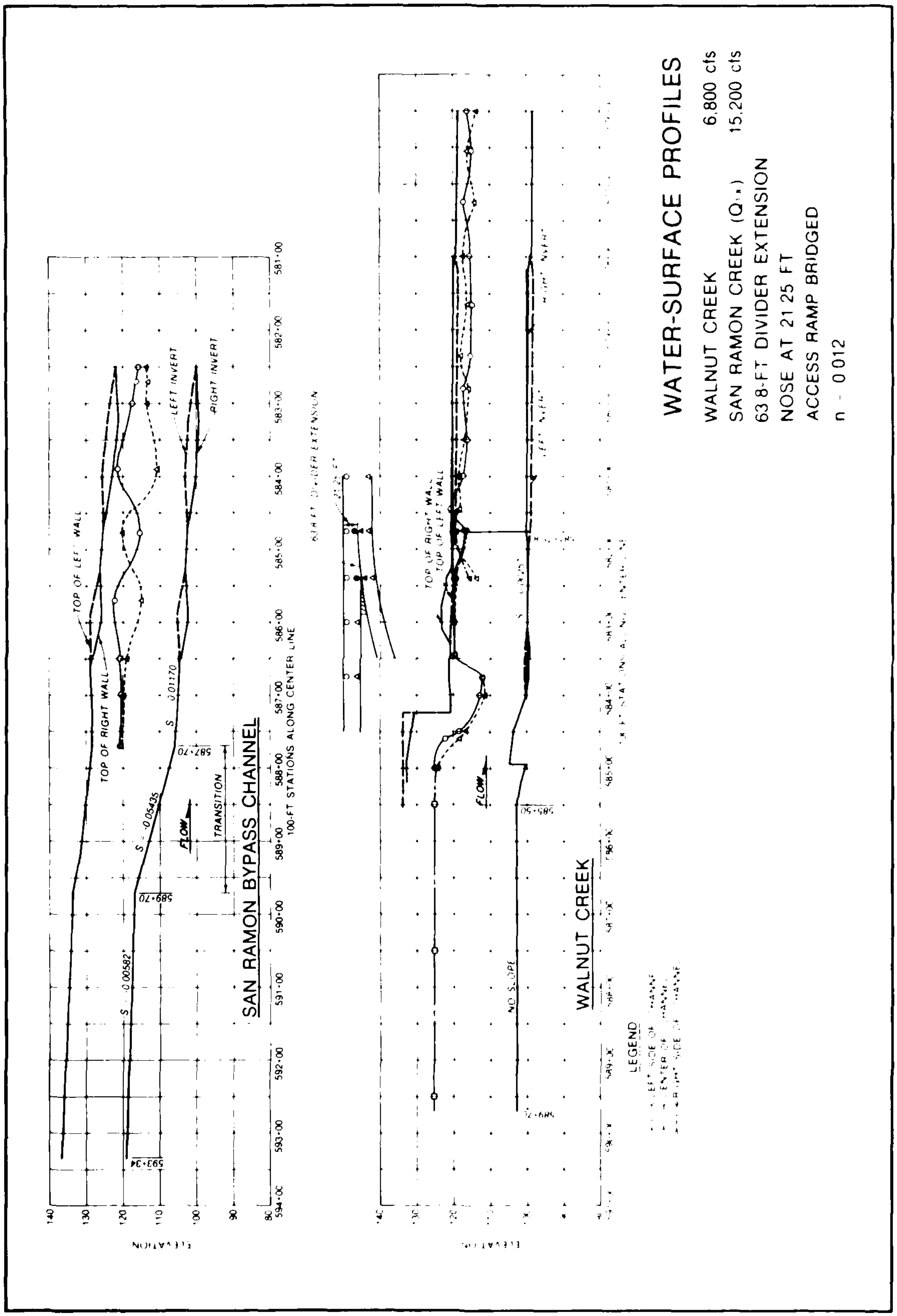
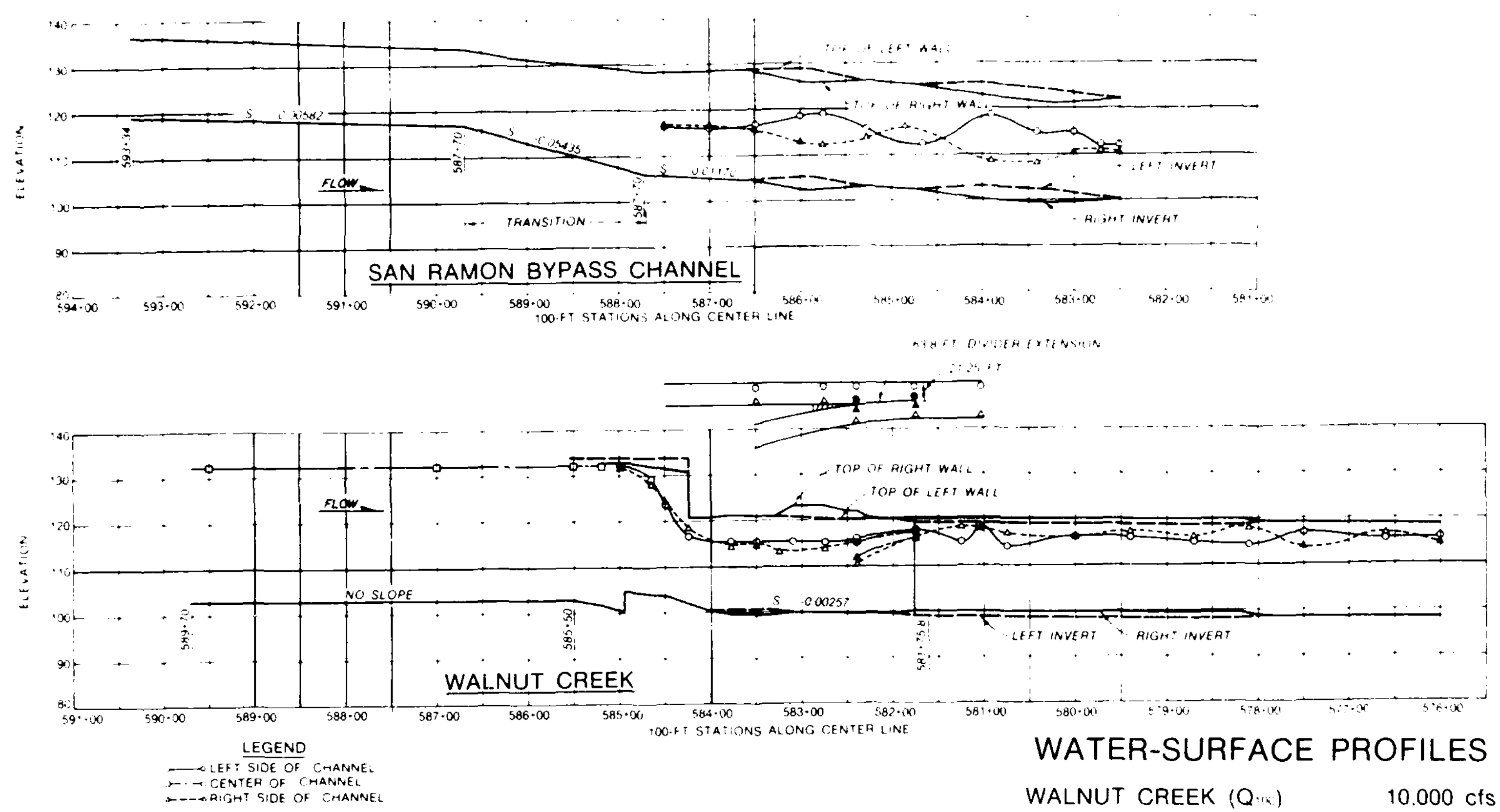

WATER-SURFACE PROFILES
WALNUT CREEK 6,800 cfs
15,200 cfs
63.8-FT DIVIDER EXTENSION
NOSE AT 21.25 FT
ACCESS RAMP BRIDGED
n = 0.012
SAN RAMON BYPASS CHANNEL
TOP OF LEFT WALL
TOP OF RIGHT WALL
LEFT INVERT
RIGHT INVERT
S = 0.01170
S = 0.05435
S = 0.00582
593+34
589+70
587+70
TRANSITION
FLOW
100-FT STATIONS ALONG CENTER LINE
ELEVATION
WALNUT CREEK
TOP OF RIGHT WALL
TOP OF LEFT WALL
NO SLOPE
585+50
LEGEND

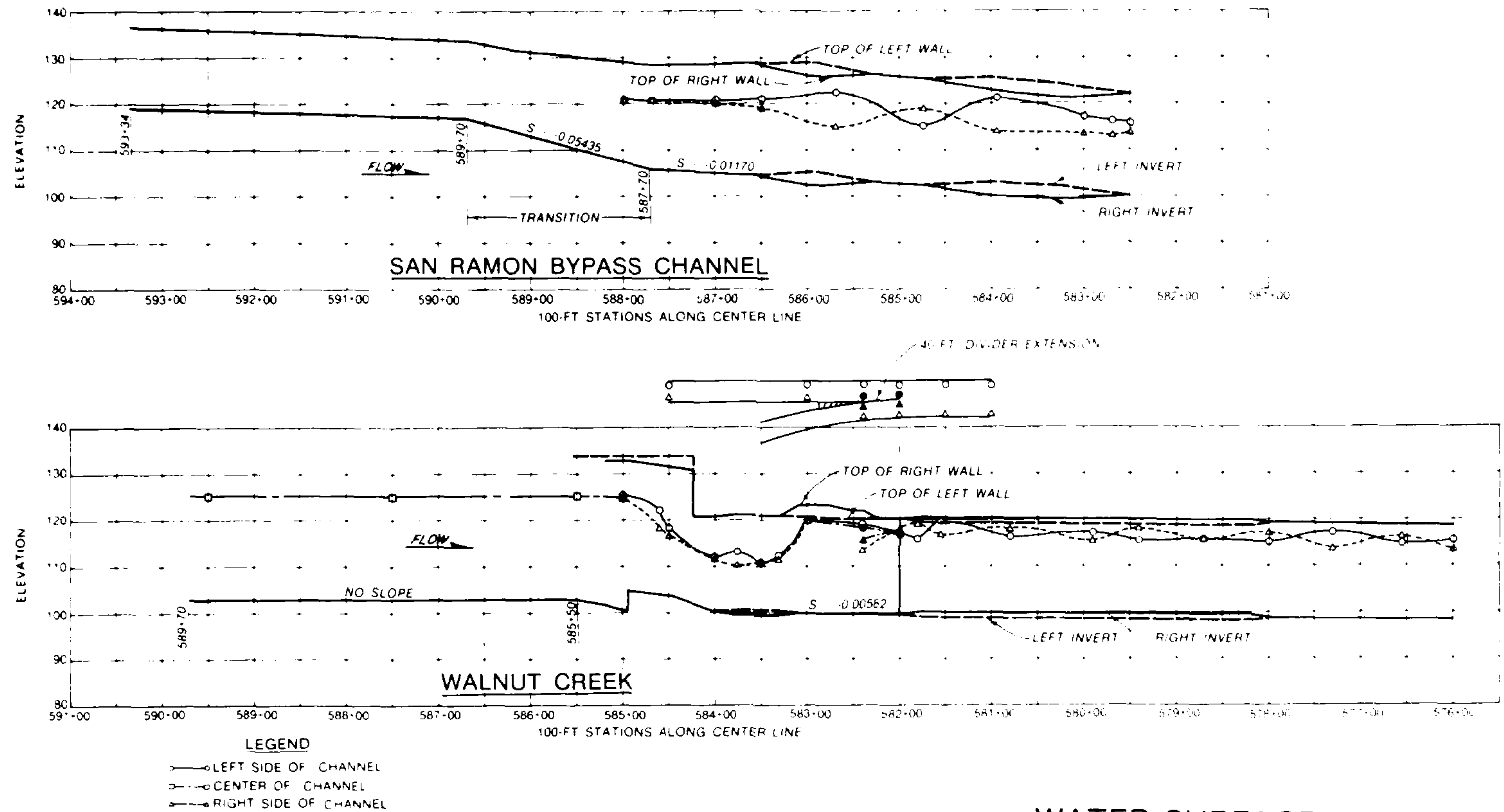
PLATE 14



WATER-SURFACE PROFILES

WALNUT CREEK (Q)	10,000 cfs
SAN RAMON CREEK	11,500 cfs

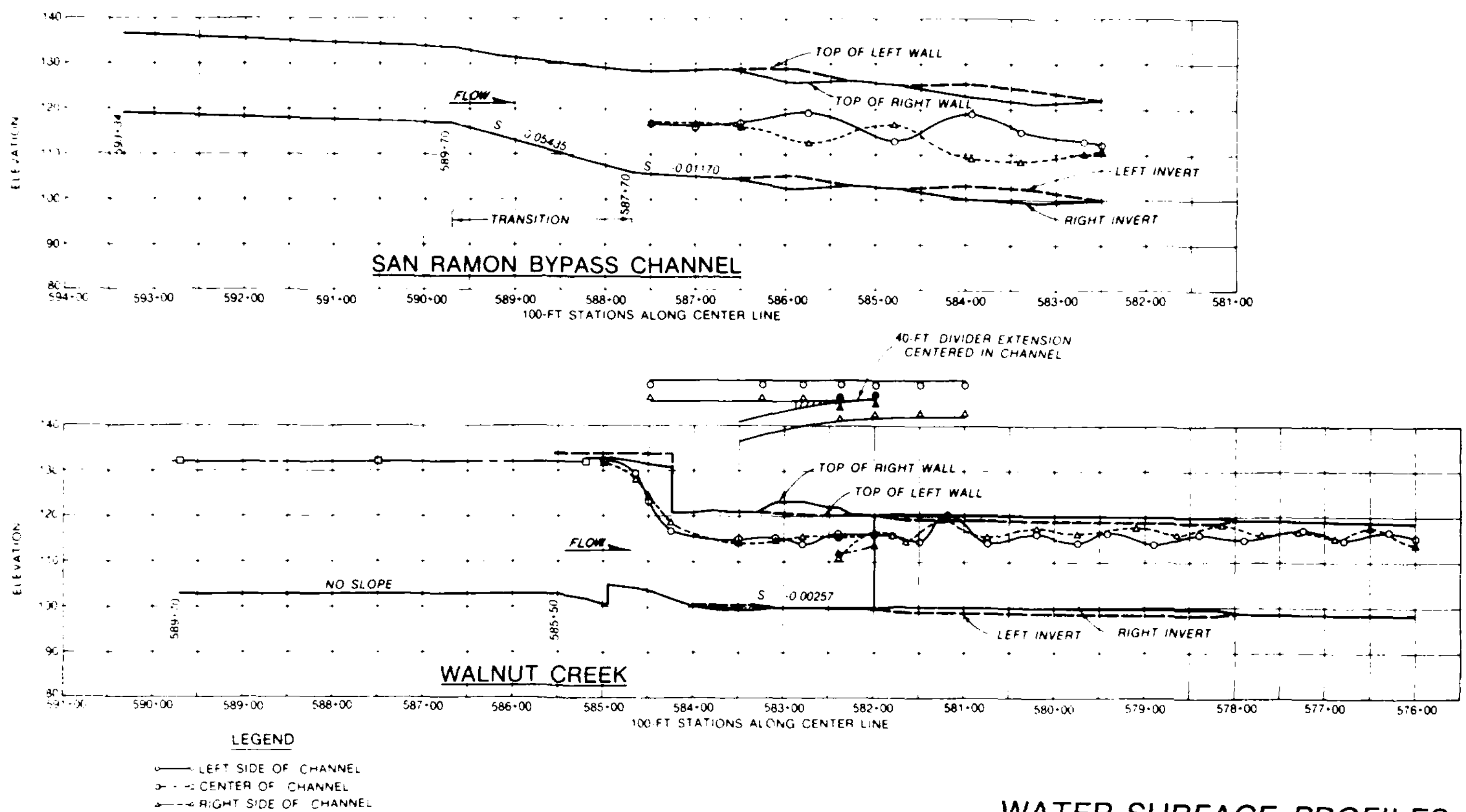
63.8-FT DIVIDER EXTENSION
NOSE AT 21.25 FT
ACCESS RAMP BRIDGED
n = 0.012



WATER-SURFACE PROFILES

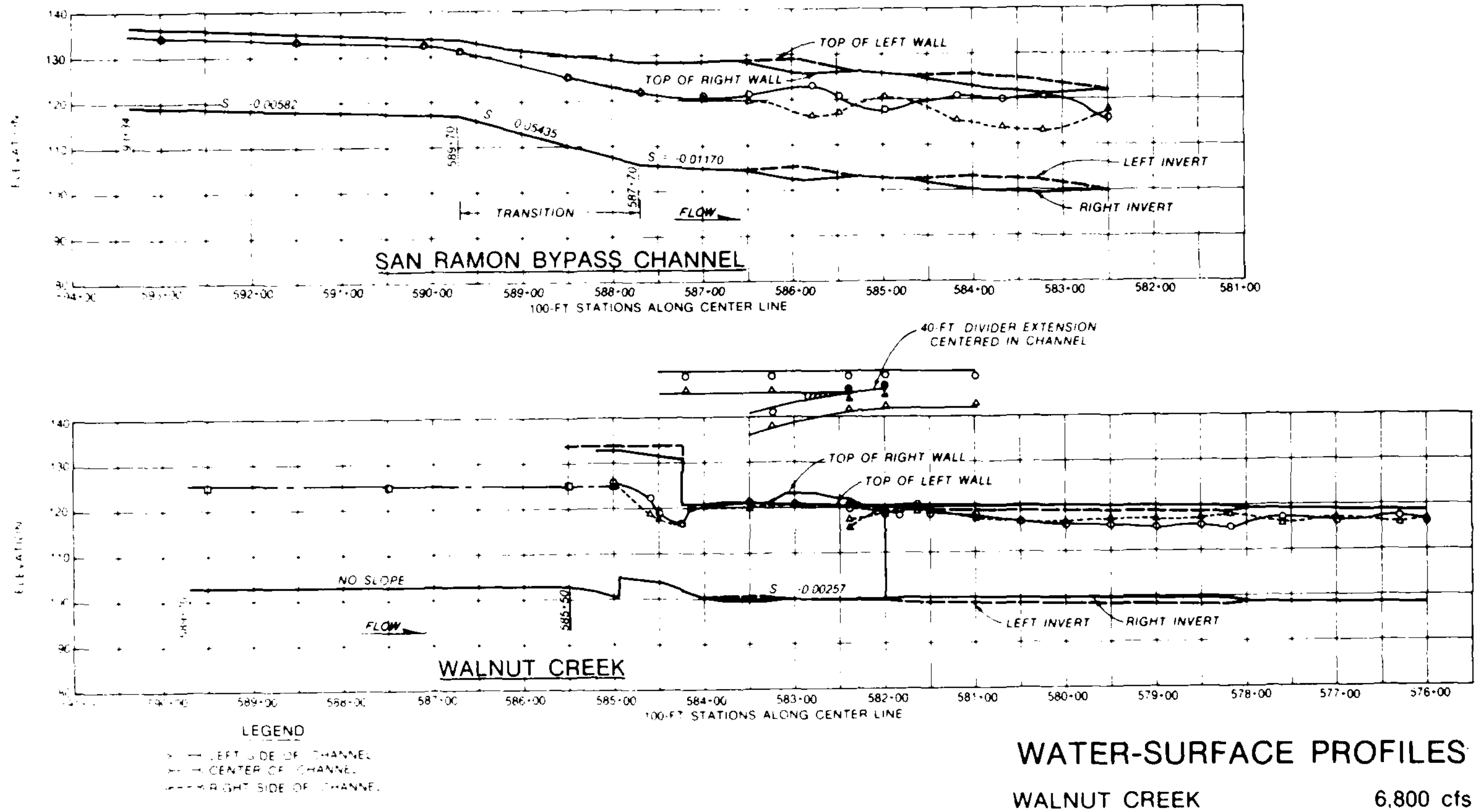
WALNUT CREEK 6.800 cfs
SAN RAMON CREEK (Q··) 15.200 cfs
40.0-FT DIVIDER EXTENSION
ACCESS RAMP BRIDGED
n = 0.012

PLATE 16



WATER-SURFACE PROFILES

WALNUT CREEK (Q_{100}) 10,000 cfs
SAN RAMON CREEK 11,500 cfs
40-FT DIVIDER EXTENSION
ACCESS RAMP BRIDGED
n = 0.012



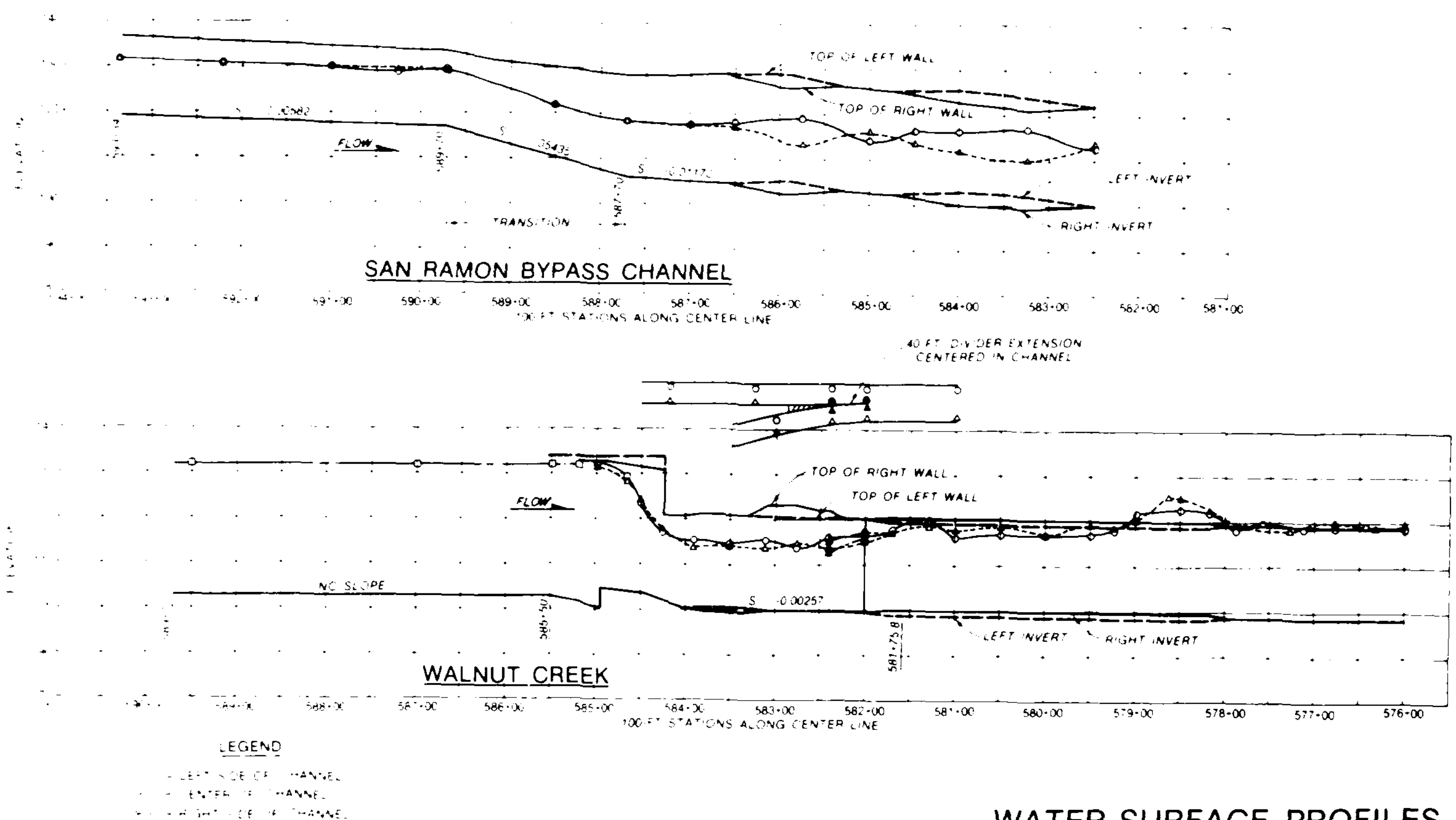
WATER-SURFACE PROFILES

WALNUT CREEK	6,800 cfs
SAN RAMON CREEK (Q_{100})	15,200 cfs

40-FT DIVIDER EXTENSION

ACCESS RAMP BRIDGED

n = 0.014



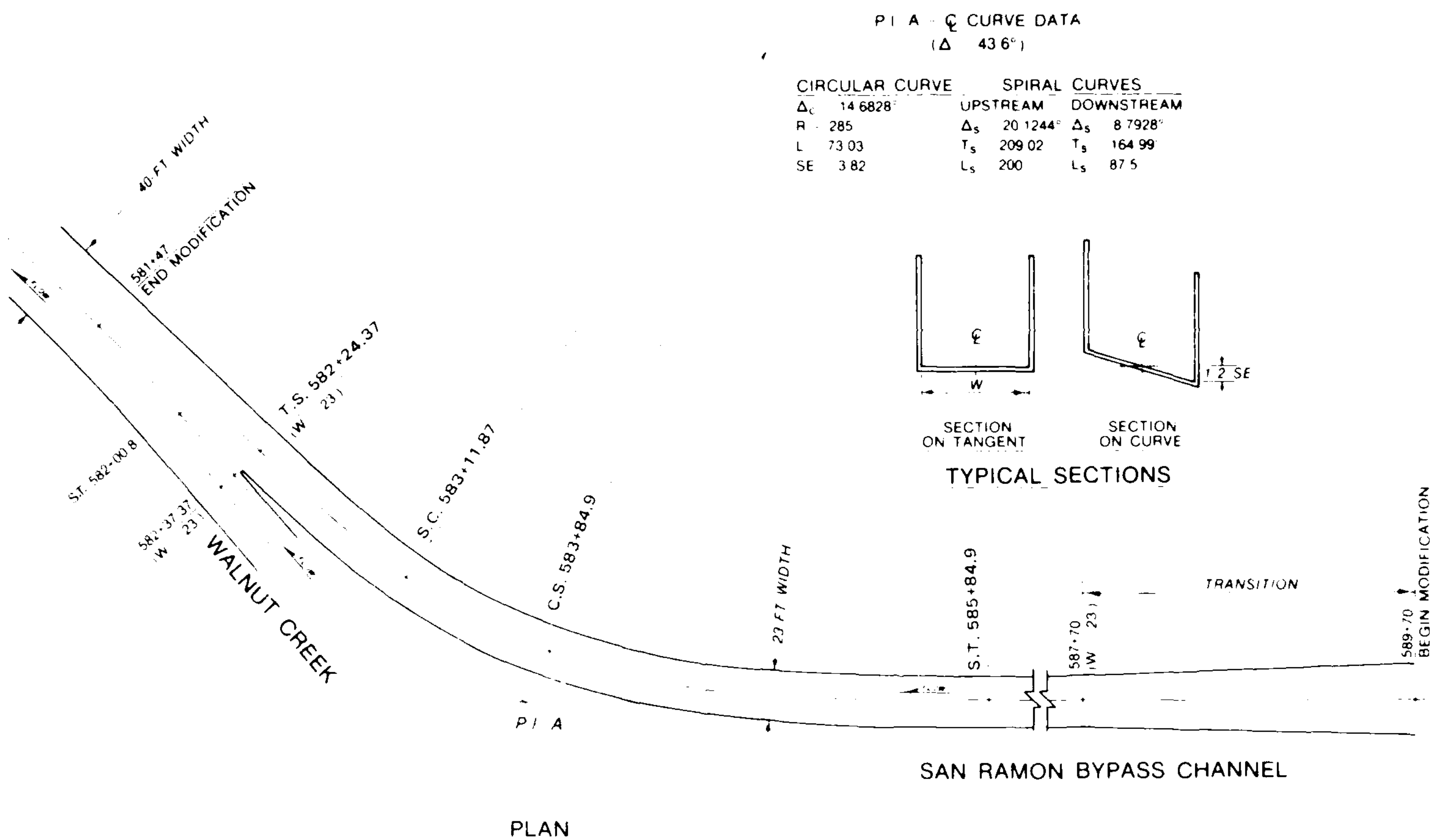
WATER-SURFACE PROFILES

WALNUT CREEK (Q_{100})	10,000 cfs
SAN RAMON CREEK	11,500 cfs

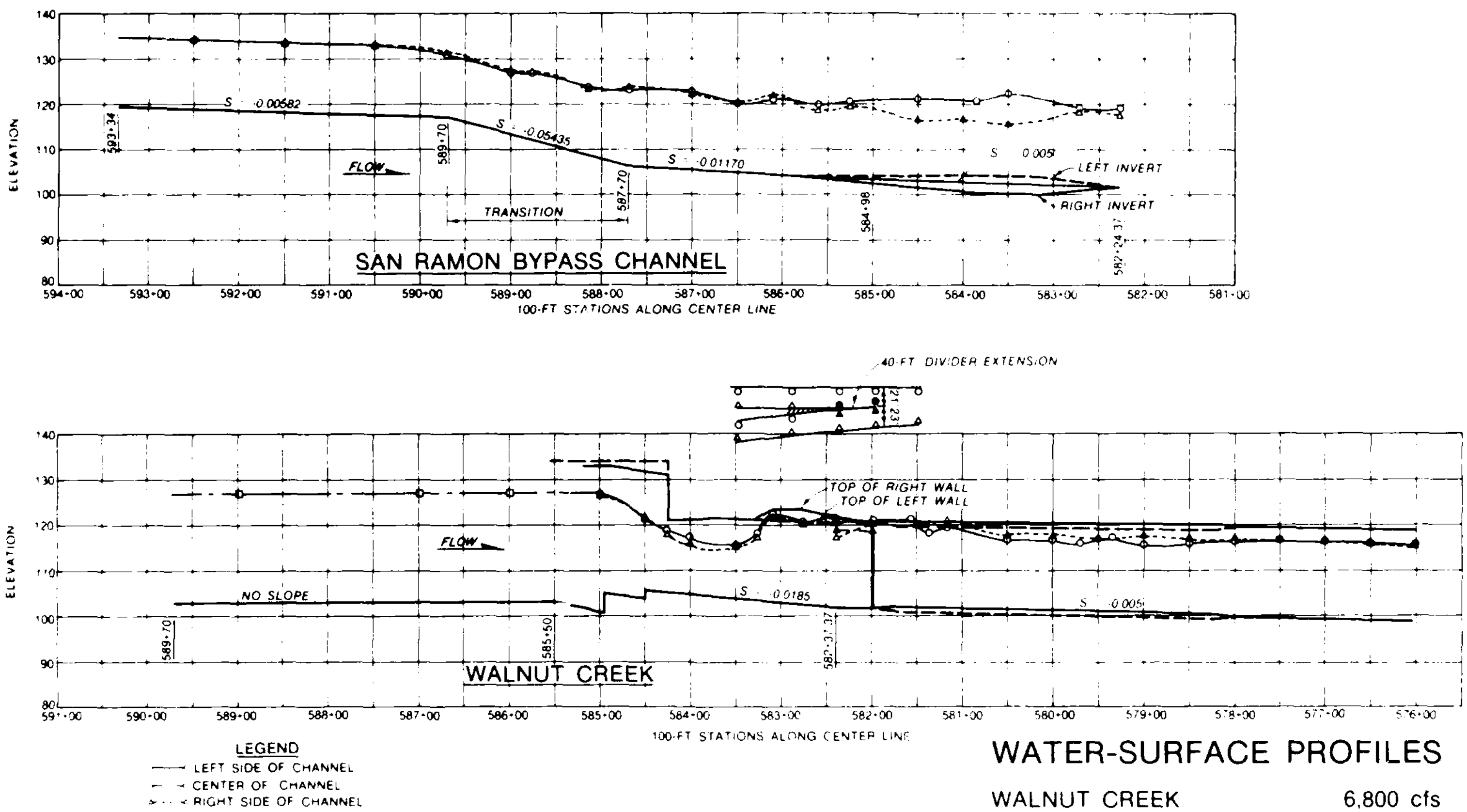
40.0-FT DIVIDER EXTENSION

ACCESS RAMP BRIDGED

$n = 0.014$



CHANNEL WIDTH AND ALIGNMENT MODIFICATION



WATER-SURFACE PROFILES

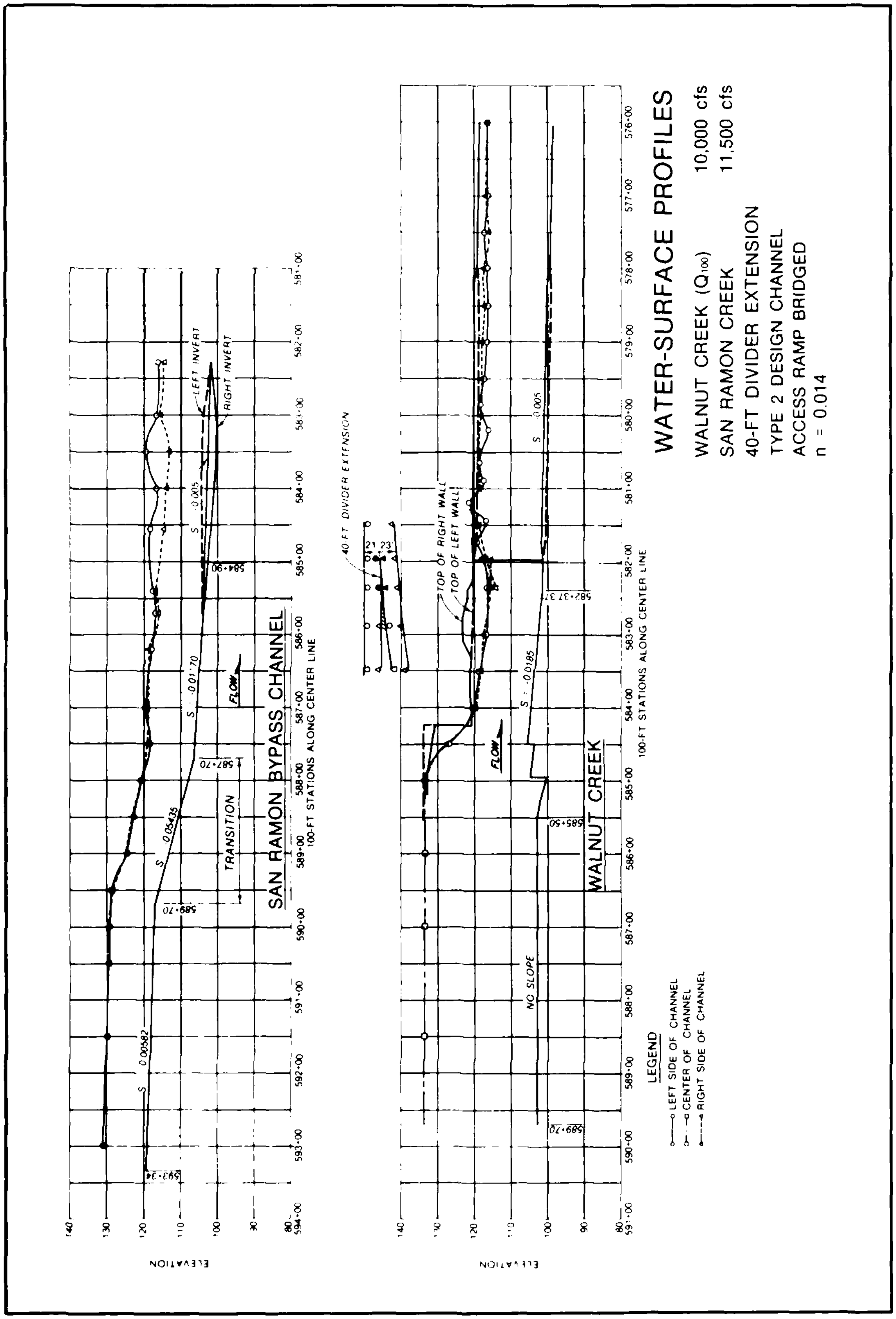
WALNUT CREEK	6,800 cfs
SAN RAMON CREEK (Q_{100})	15,200 cfs

40-FT DIVIDER EXTENSION

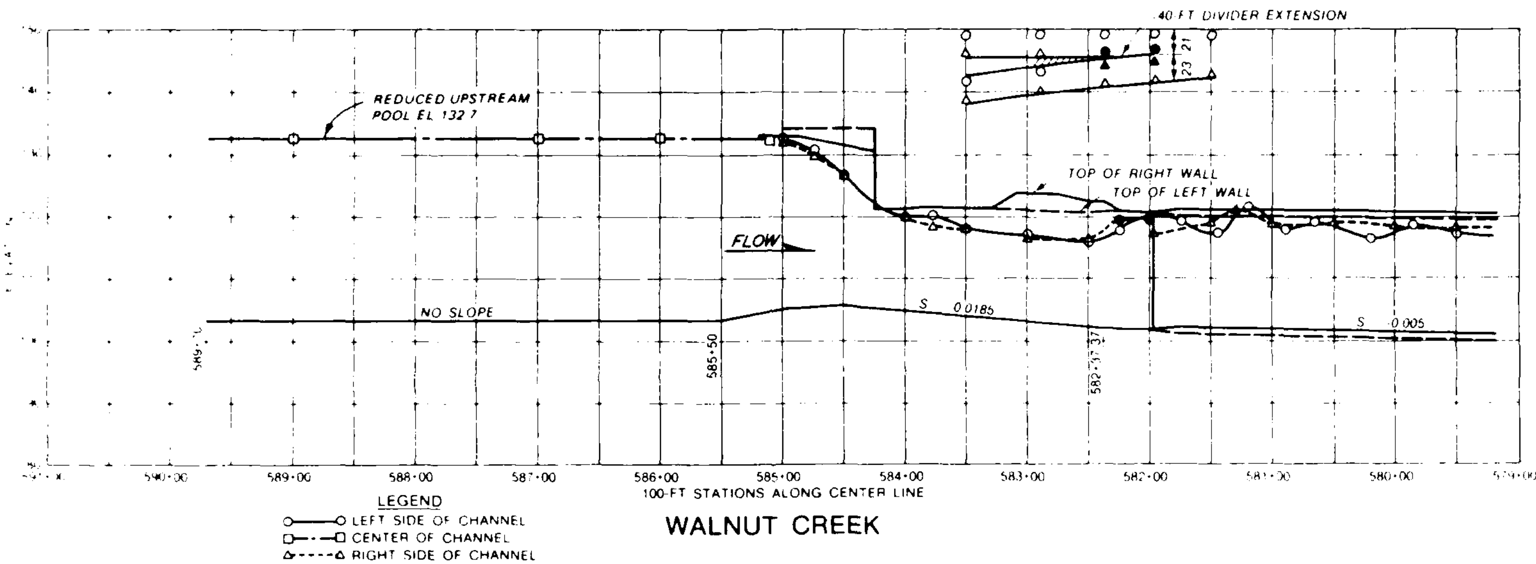
TYPE 2 DESIGN CHANNEL

ACCESS RAMP BRIDGED

n = 0.014



WATER-SURFACE PROFILES
WALNUT CREEK (Q100) 10,000 cfs
SAN RAMON CREEK 11,500 cfs
40-FT DIVIDER EXTENSION
TYPE 2 DESIGN CHANNEL
ACCESS RAMP BRIDGED
n = 0.014
SAN RAMON BYPASS CHANNEL
WALNUT CREEK
100-FT STATIONS ALONG CENTER LINE
ELEVATION
LEFT INVERT
RIGHT INVERT
TRANSITION
FLOW
40-FT DIVIDER EXTENSION
TOP OF RIGHT WALL
TOP OF LEFT WALL
NO SLOPE
LEGEND
LEFT SIDE OF CHANNEL
CENTER OF CHANNEL
RIGHT SIDE OF CHANNEL



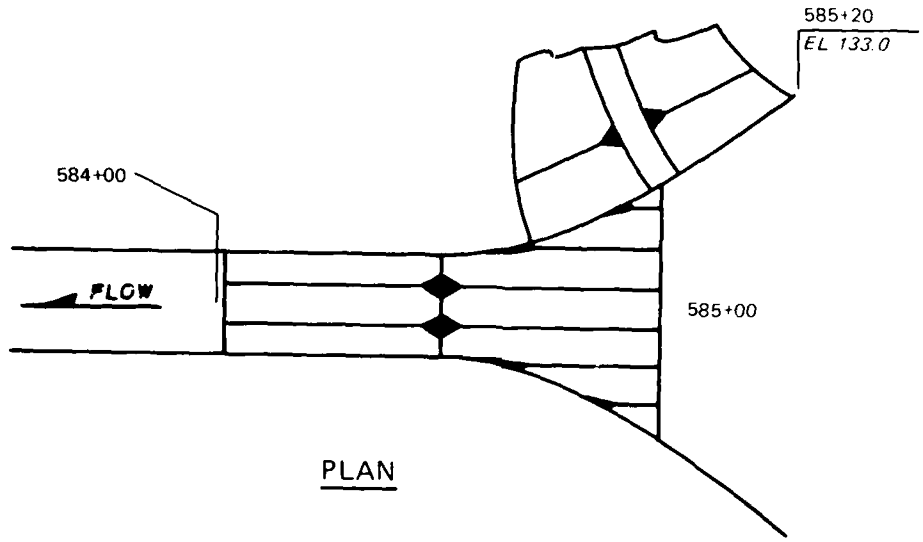
WATER-SURFACE PROFILES

WALNUT CREEK (Q_{100})	10,000 cfs
SAN RAMON CREEK	11,500 cfs

TYPE 2 DESIGN CHANNEL

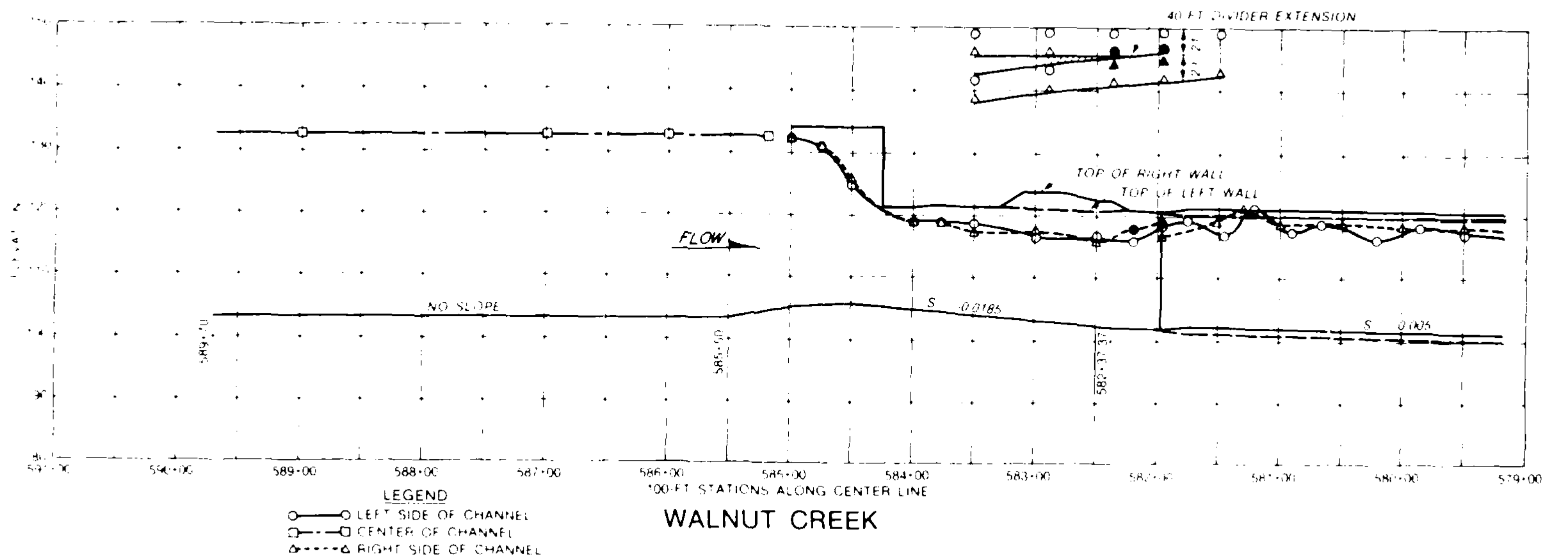
ACCESS RAMP BLOCKED

n = 0.014



PLAN

SYMMETRICAL
ENTRANCE



WALNUT CREEK

WATER-SURFACE PROFILES

WALNUT CREEK (Q_{100})	10,000 cfs
SAN RAMON CREEK	11,500 cfs

SYMMETRICAL ENTRANCE

$n = 0.014$

END
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